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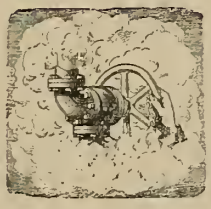

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CASSIER'S MAGAZINE.

VOL. XIV. MAY, 1898. No. 1.

JOHANNESBURG OF TO-DAY.

WITH SOME GENERAL NOTES ON THE RAND.

By A. Cooper Key.

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HENWOOD'S BUILDINGS, MARKET SQUARE.

JOHANNESBURG, or the "Golden City," as it is frequently called, is situated in the centre of an auriferous tract of country, termed the Witwatersrand (White Water's Range), in the southern portion of the South African Republic. The range is at an average height of 5000 feet, or so, above sea level, and forms the watershed of two great river systems. One of these is the Crocodile or Limpopo, discharging into the Indian ocean, 75 miles above Lourenço Marques; the other, that of the Vaal and Orange, find-

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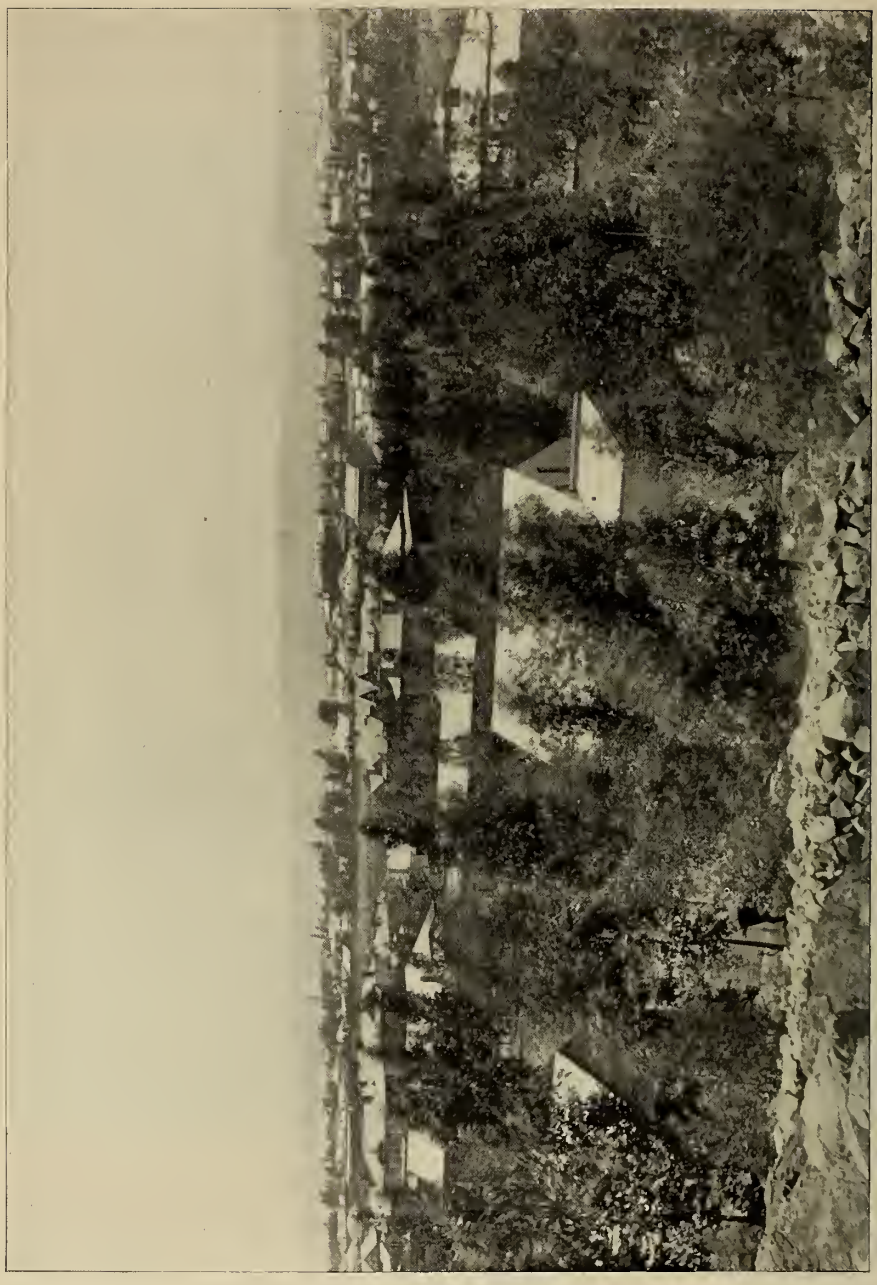

A VIEW OF JOHANNESBURG FROM THE NORTH.

FROM A COPYRIGHTED PHOTO BY BARNETT, JOHANNESBURG.

ing its mouth in the South Atlantic at Port Nolloth, 285 miles above Cape Town.

Johannesburg had, at the last census, taken in 1896, a population of 100,000 within a three-mile radius, which was practically equally divided between whites and blacks. The town is a pleasant one under its best conditions; but the red dust storms, which are frequent in the winter, *i.e.*, from May to the middle of September, are both disagreeable and dangerous,—disagreeable to those having to stay in the town, and dangerous to people suffering from any weakness of the lungs.

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ECKSTEIN'S CORNER, SHOWING WROUGHT IRON VERANDAHS.

It must be explained that Johannesburg is a city of only ten years' growth. It is generally dignified by the term city, possibly in accordance with American ideas, though the British definition does not apply. Its progress has been so rapid and the means at the disposal of the local authority so small that it has been found impossible to provide proper roads. Only the principal thoroughfares are macadamised. In many instances the streets are worn down "veldt," with a few boulders scattered about indiscriminately.

It will thus be easily seen that the friction of traffic on the sandstone, more especially where the draught is increased on gradients, causes a disintegration of the rock formation, producing, consequently, large quantities of dust. So annoying and damaging is this dust plague that it is a common custom to place a notice on the entrances to shops and offices: "Please come in! Closed on account of the dust." The question of road making is one which will have to be grappled with, though the making of 180 miles of streets is a matter not lightly to be taken in hand.

At present Johannesburg has no sewerage system, though a multitude of schemes have been put forward. Naturally, this question will have to be settled before systematic road making is taken in hand. The great difficulty in the matter of sewerage is the alleged insuffi-

COMMISSIONER STREET, FROM THE STOCK EXCHANGE.

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ciency of water supply. A leading engineer of Johannesburg has stated it as his opinion that a water-borne system is out of the question on the score of expense. Considerable discussion has lately taken place on this important matter, and Liernur's pneumatic system, which has considerable vogue on the Continent of Europe, is one which has been strongly advocated in some quarters. The government of the Republic has taken the matter out of the hands of the local authorities, having decided to promulgate a scheme of its own.

Road construction, as practised in Johannesburg, exhibits some peculiarities. The usual course is to shoot down quantities of the material, the bulk of which is "country rock" of the mines, and to have it broken on the road by coolie labour. There are frequently large boulders, and no attempt apparently is made to bind the contractors to supply to gauge, as is customary in English towns. It is, however, only fair to add that this state of affairs is being remedied. The system of breaking must be very costly, and if one might venture to make a suggestion to the powers that be, a more economical method would be to break the rock by a modern crusher at some central station. The feeble efforts of the coolies in this direction have an exasperating effect on civilised onlookers.

So little attention being paid to the above noted detail, it will be understood that little trouble is taken in road making as a whole. Steam rollers are used, but with these the analogy to usual practice ends. One must not, however, be too critical on the authorities, as it would be both expensive and discouraging to make proper roads, and then have to tear them up after a while to put in the sewers.

Trams are quite a feature of Johannesburg's life. As a whole, the service may be regarded as an admirable one. Punctuality is strictly observed, and good running time is made (about six miles per hour). The Johannesburg City and Suburban Tramway holds an exclusive concession from the government, dated April, 1889, to lay and work lines in the public streets of Johannesburg for a period of thirty years. There are at present about nine miles of tramway in existence. The main line runs parallel with the main reef outcrop and consequently near the mines. There are other lines to the suburbs.

Horse and mule traction is at present employed. "Many a time and oft" has the company applied for powers to substitute electrical or mechanical haulage, but a deaf ear has been turned to its requests.

Early in the year 1897 a provisional concession was granted to some other people to lay and maintain lines, and to use electrical traction anywhere within nine miles of Johannesburg, provided such lines did not encroach upon the original company's territory. The withholding of powers sought by the pioneer company and the granting of them to others gave cause to considerable adverse criticism. It is, however, satisfactory to note that the Raad has refused to ratify the provisional agreement, which consequently has no effect.

Animal traction is quite out of character with the general up-to-date line of the Golden City, and the several electrical or cable systems in vogue in Europe and America should be considered by the company's engineers and every effort made by them to bring about a change in the attitude of the government.

Tram fares, as compared with those of London, are excessive, anything over ½ mile being 6d., the lowest charge being 3d. Cab-riding in Johannesburg is an exciting luxury, very different to the easy motion of that vehicle which has been well termed "the gondola of the London streets."

Most of the vehicles are Cape carts, which have so extensive a vogue throughout South Africa. These are somewhat similar to the English dog cart, though built on heavier lines in order to withstand the terrific strains of bad roads with three-inch ruts. Heavy axles are requisite when crossing the wide, roughly-stoned gutters of Johannesburg. More frequently than not,

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THE SOUTH AFRICAN MUTUAL ASSURANCE SOCIETY'S BUILDING.

the aim of the hastening Jehu seems to be to take these rough places at highest possible speed.

Speaking of cab fares, these are for distance 100 per cent. above the London rates, though the same as those prevailing in most provincial towns of Great Britain. Somewhat curiously the time charge is 7s. 6d. per hour—three times that obtaining in London. But, having regard to the high cost of forage for the "links" (two horses are invariably used in each cart), to heavy wear and tear, and also to the general extravagant scale prevailing, these rates are, perhaps, not excessive. Differing from London charges, the fare is so much per person.

The bicycle fever has affected Johannesburg in common with most South African towns. Raleighs, Singers, Rovers and Swifts are everywhere to be seen, together with a fair proportion of American types—Clevelands, Victors, and E. H. Howards.

Johannesburg is not without its fine buildings. The principal ones are in the central portions of the town, but the suburbs have some striking residences, chief among which are Mr. Eckstein's house at Doornfontein, and that of Mr. Hennen Jennings at Parktown, three miles from Market Square.

The Chamber of Mines building has been characterised by competent critics as the best specimen of architecture in the town. Certainly it presents a very handsome exterior. Of the interior work, the wood carving and wrought iron work is specially noticeable. The building contains a large hall, which, in addition to being used for the meetings of the governing corporation, is lent by them for those of scientific societies; as,

for instance, the Geological Society of South Africa, the Association of Engineers and Architects, and the Chemical and Metallurgical Society. There are also general offices, and, on the third floor, a geological museum and a library. The geological collection is a rather poor one, but efforts are being exerted to make it more valuable. It has, quite recently, been materially benefited by the permanent loan of the Geological Society's collection.

Next door to the Chamber of Mines £12,000. This building, besides being the abode of the firm whose name it bears, accommodates Messrs. Neumann & Co., and the officials of that gigantic undertaking, the Rand Mines, Ltd.

As far as the public is concerned the most important is the new Post Office in Market square. This was commenced seven or eight months ago, and will probably be completed by the middle of 1898. The place where this important institution is now housed is miserably inadequate. One really won-

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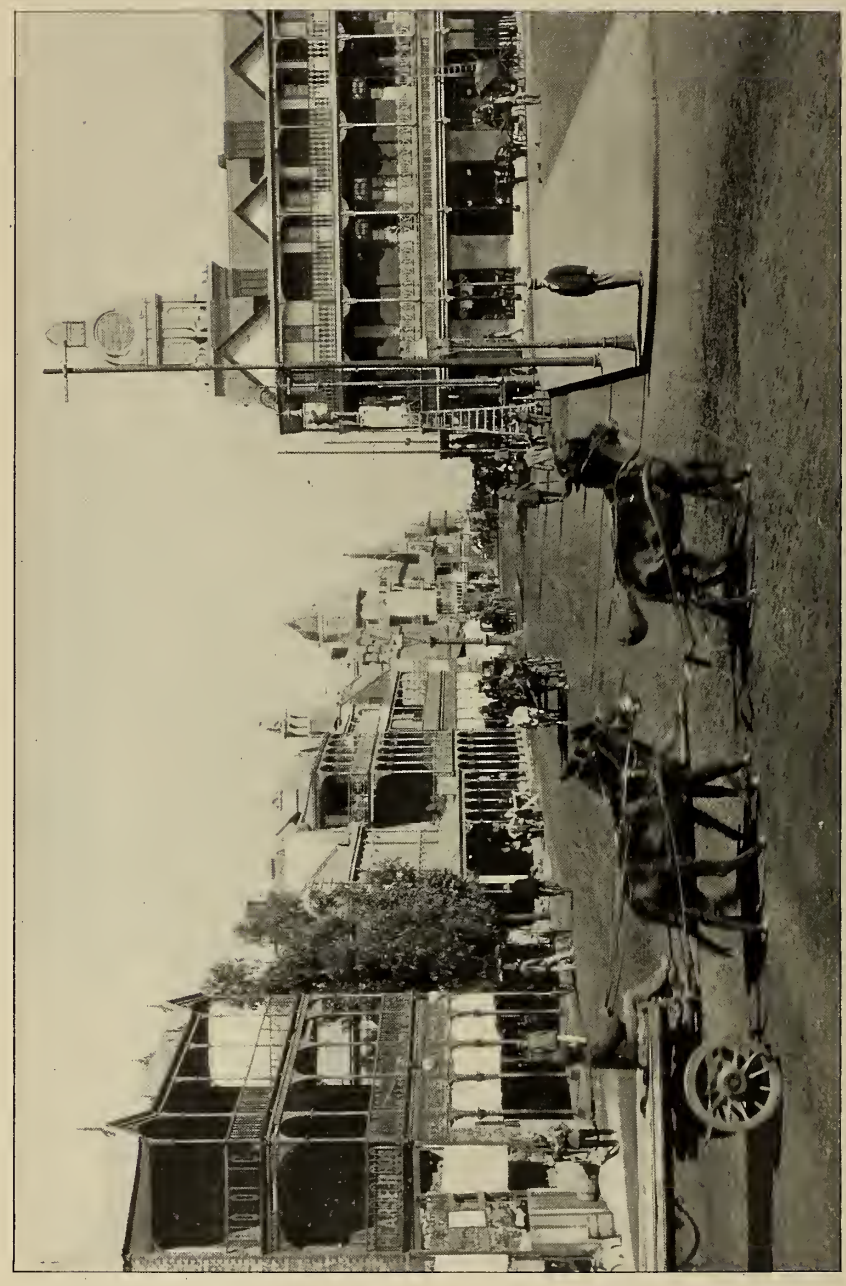
STEYTLER'S BUILDINGS.

is the Government Bank,—De Nationale Bank,—a building somewhat dwarfed by its neighbours. On the opposite side to this is the handsome pile of the Robinson Banking Corporation. The street which divides these two is at the particular spot kept sacred to financial men, especially the members of the Stock Exchange. Alongside the Nationale Bank is Eckstein's building, a structure which is noticeable on account of its splendid iron work verandahs, which are said to have cost nearly

ders how the work is done with the rapidity which characterises it. It is no uncommon thing for £1000 worth of stamps to be sold on the morning the European mail leaves. As there are only three clerks selling stamps, some idea will be gathered as to the work on their hands.

The box system is in use at Johannesburg, but at present the number bears an undue proportion to the applicants. As much as £5 premium is sometimes paid for the transfer of a box. Doubt-



PRITCHARD STREET, JOHANNESBURG.

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less this state of things will be remedied in the new building. One great improvement in the Post Office service was the inauguration, in December, 1896, of a house-to-house delivery. This has done much to relieve the congestion.

The building of the Consolidated Deep Levels and the Exploration Company, now under construction, will, undoubtedly, rank as one of South Africa's finest buildings. In fact, the front façade will probably rank as one of the finest architectural compositions on the whole Continent. The Bank of Africa, too, has recently taken itself to temporary premises, while its present building is being pulled down and a new one erected. This is significant of the improvement of the town, as, three years ago, the bank was one of the finest buildings.

Let us run out to Springs, the eastern terminus of the "Rand tram" section of the Netherland Railway, and work our way back gradually. Near the station we have the Railway Colliery, the Cassel, and the Clydesdale. "The" Springs, as the place is more correctly called, is about thirty miles east of Johannesburg, and it lies five miles to the south of the supposed extension of the Main Reef series. The most easterly point at which gold mining is proceeding is the Modderfontein mine, which has lately contributed 3500 ounces to the aggregate monthly output of the Rand. Up to June last work of an exploratory character had been going on at the Modderfontein extension, but it was stopped, as the results gave no encouragement.

Near the Modderfontein are the New Kleinfontein, a very important producer, the Van Ryn and the Van Ryn West. There are several other companies in this detached district; for instance, the Kleinfontein Central, the Chimes, the Benoni, and the Chimes West; but they are all shut down—mainly on account of lack of funds.

Near Brakpan are one or two collieries and also an undertaking which may take a very prominent part in the Rand's future. This is the Rand Central Electric Works. These commenced supplying current to customers, along the thirty miles of country from their generating station to a point some distance west of Johannesburg, early last year.

A little west of Boksburg, which is the next station, are the mines of the East Rand Proprietory group. There are five properties connected with that association, the Angelo, the Driefontein, the New Comet, the Agnes Munro, and the Cinderella, extending over four miles of "outcrop." At present only the first and third are producing. With forty stamps the Angelo is making wonderful profits; £10,000 has been the result the last few months. The New Comet's monthly production is about 3000 ounces. The Driefontein will probably be producing this year. An enormous joint mill has been in course of erection for these properties.

At the Ginsberg we have a promising Barnato mine, for, with 40 stamps, it is making £6000 and £7000 a month. North of this mine we have, in the Balmoral, a mine which has recently entered the producing stage; but it is one which, owing to its heavy capitalisation, is hardly likely to make adequate distributions to its shareholders.

The next mine is Knight's, which was one of the first Rand companies. Lately the mine has not been giving a satisfactory account of itself, but as it is in a transition stage, little should be said on this point. Adjoining this is the Glencairn, which restarted crushing last July. To the south, is the Glen Deep. Next is the Rose Deep, which started last October, producing as much as 5600 ounces during a short run of twenty days.

The Simmer and Jack is one of the largest mines on the Rand, and the company started half of its 280-stamp mill last November. Below the Simmer are the Rand Victoria mines and some unfloated claims belonging to the Goldfield Deep. Also on the farm Elandsfontein No. 1, but lying farther west, is the Geldenhuis estate, which is one of the ten largest producers of the Rand, its monthly output being generally 7500

or 8000 ounces. Perhaps the mine is the most erratic as regards its profit of any in the fields. For instance, in September, 1896, the amount was only £1669; in November it was £9352; it had fallen to £5420 in January, 1897. Since then the movement has been progressive, £15,500 having been recorded in October, 1897.

With its northern boundary about four or five hundred yards from the outcrop, comes the first deep-level producer,—the Geldenhuis Deep. Considerable disappointment was caused by the initial results at this mine. The total profit for the year 1896 was £16,946. Sorting was introduced at the mine in April, 1897, with the consequence that the grade of ore crushed became much superior.

The next outcrop mine is the Jumpers, which has its corresponding "deep." The former is somewhat handicapped by an out-of-date light stamp mill. In its "palmy days" the mine made profits of £7000 or £8000 a month. But that was long ago, and the average last year was about £5000, and constantly improving. At the "deep" the mill is expected to be ready early in 1898, but this is dependent on the arrival of machinery from England.

At the mine adjoining the Jumpers on the east,—the New Heriot,—a great improvement in gold value is evidenced. For a distance of about one mile there is an exceedingly rich patch of ground, which includes that mine and the Henry Nourse. This fact is evidenced in the returns very emphatically. The Geldenhuis estate's and the Jumpers' average recovery in 1896 was 9.04 dwts. Against this the Henry Nourse recorded 16.65 dwts., and the New Heriot 14.84 dwts.,—an improvement, approximately speaking, of 6 dwts.

The Nourse Deep, which owns the immediate dip of the Henry Nourse for a distance of half-a-mile, has the largest claim area of any of the Rand mines' subsidiaries. With the Jumpers Deep it shares the dip-ground of the Heriot. This mine started crushing last November. In the Henry Nourse and the Heriot the reefs are steeply inclined. In the "deep," however, the reefs assume their normal inclination. The gradual flattening-out process, which they undergo in entering the property, causes a distortion in the formation. Although dipping at 80 degrees at the outcrop of the New Heriot, the dip in the lower levels is only about 45 degrees.

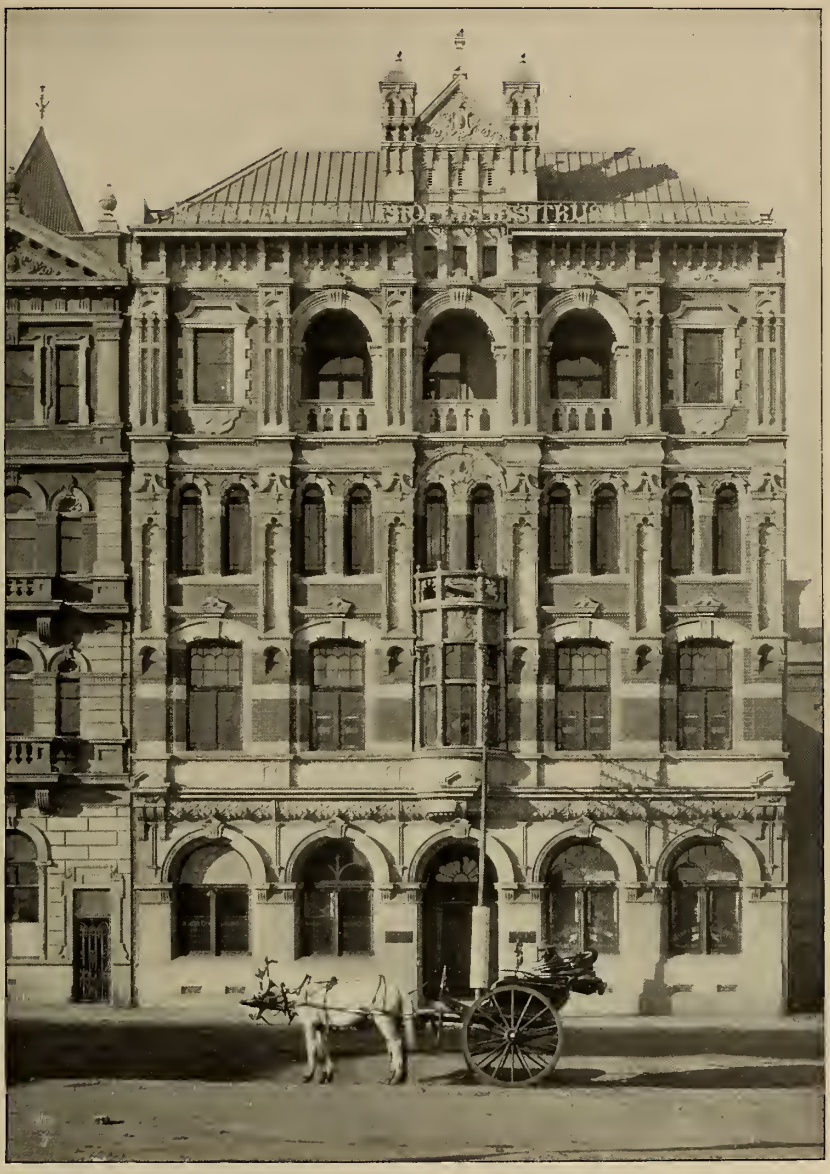
The inquiry may have struck the reader as to whether this increase in value bears any connection with the disturbed nature of the country,—whether faulting causes enrichment, or whether enrichment in proximity to faults is a mere coincidence. This is a matter on which opinion is widely divergent. In the portion of the Bonanza mine nearest the Johannesburg Pioneer the reef shows an important appreciation in value when it is contiguous to an intrusion. This is also the case at the Nigel mine, situated about 35 miles southwest of Johannesburg, where the country is highly faulted.

Professor Becker, of the United States Geological Survey, considers this improvement in grade, evidenced at the last named property, to be a mere accidental occurrence; others are of opinion that the liquid carrying the gold particles may have more readily run into the cracks and crevices than elsewhere. The latter theory at least seems tenable.

West of the Henry Nourse comes the metropolitan portion of the George Goch. Here we come across the large dyke which throws the series southwards. The George Goch fields are of only about half the gold values shown in the Heriot and the Henry Nourse. For instance, in June, 1897, the mill yield was 4.50 dwts., and that from tailings 3.74 cwts.

The Wolhuter, at £860,000 capital for 172 claims, is a heavily capitalised proposition. But with £6000, £7000 and £9000 a month, running 100 stamps, it is earning sufficient to pay a dividend of 10 or 12 per cent., and declared its first at the former rate at the end of October, 1897.

Due south of this mine is the Bezuidenville borehole. During the year 1895 this was drilled to a depth of 3728 feet.



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THE AFRICAN CITY PROPERTIES TRUST BUILDINGS.

Westward of the Wolhuter comes the Meyer and Charlton, then the City and Suburban, which has lately been noticeable chiefly on account of its large and increasing profits. The west end of the City and Suburban marks the entry into a zone of great richness. The Jubilee and the Salisbury both go about 9.50 dwts., but this might probably be improved by efficient "sorting" appliances.

The Wemmer is fifty per cent. higher even than this, giving as much as 14.42 dwts. The Ferreira mine record in 1896 was 22 dwts. Monthly profits of £28,000 to £30,000 on crushings of 10,000

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NATIVE WORKERS AT THE NEW PRIMROSE MINE.

tons are regularly shown by this mine.

Covering the dips of the Ferreira and the Wemmer is the Ferreira Deep, a property held in almost equal shares by the Rand Mines and the Barnato Consolidated. The potentialities of this concern, should the results follow the splendid record of the Ferreira, are vast. Shaft sinking was commenced in March, 1897, and it was estimated that the reefs would be struck at depths not exceeding 1300 feet in from eighteen to twenty months from that date.

The Rand's premier mine,—the Robinson,—in 1896 showed a result not quite one dwt. less than that recorded by the Ferreira. Doubtless this is accounted for by the fact that a specialty is made of "sorting" at the latter mine. The falling off of the Robinson's ore grade compared with the previous year is attributable to the scarcity of native labour, rendering it necessary to stope the reefs at those points which gave the largest production of ore with the smallest employment of labour. Under these circumstances the grade of rock obtained from the South Reef and Main Reef Leader was not so high as if the narrower, and therefore richer, portions had been attacked.

Five and two-thirds claims at the extreme northwest constitute the holding of one of the most interesting of the Rand's companies,—the Johannesburg Pioneer. Its small capital allows high percentage dividends to be paid; but the mine has pretty well come to the end of its tether, and will be exhausted probably in 1898, though mines often last much longer than forecasted.

It is interesting to note that the ground below the outcrop of the Main Reef series in this portion of the Rand, *i. e.*, the western half of Greater Johannesburg, is taken up for a distance of several miles. East and West the holding of dip ground is not so great; still it is considerable. The mind reels before the vast possibilities tied up in the exploitation of these enormous tracts of deep ground.

There is nothing of importance beyond this until one reaches the Champ d'Or. This mine has a recovery value of 40s. per ton milled, but has probably passed through more vicissitudes than any other on the Rand. At one time it was in great financial straits; more recently rich ore was taken from too near the shafts, one of which subsequently caved. Recent results, owing to excellent management, have been good.

Ground on either side of the Champ d'Or and also on the dip is owned by the French Rand Company, which has a capital of £560,000, plus a debenture issue of £200,000. This mine will probably start with 60 stamps in August

In places the reef may be covered with a considerable thickness of alluvial wash, and in many it may be of exceeding low-grade and unpayable. On the other hand, there is little reason to doubt that payable, even rich, patches exist. Such questions can be answered only by extensive exploration work. The possibilities are enormous.

There is every probability that the output of the Rand for 1897 will reach the magnificent aggregate of 3,000,000 ounces, worth, say, £10,500,000! This means that the Rand will have secured in a twelvemonth one-hundredth of the world's total during practically half a century.

The future of the Rand depends, per-

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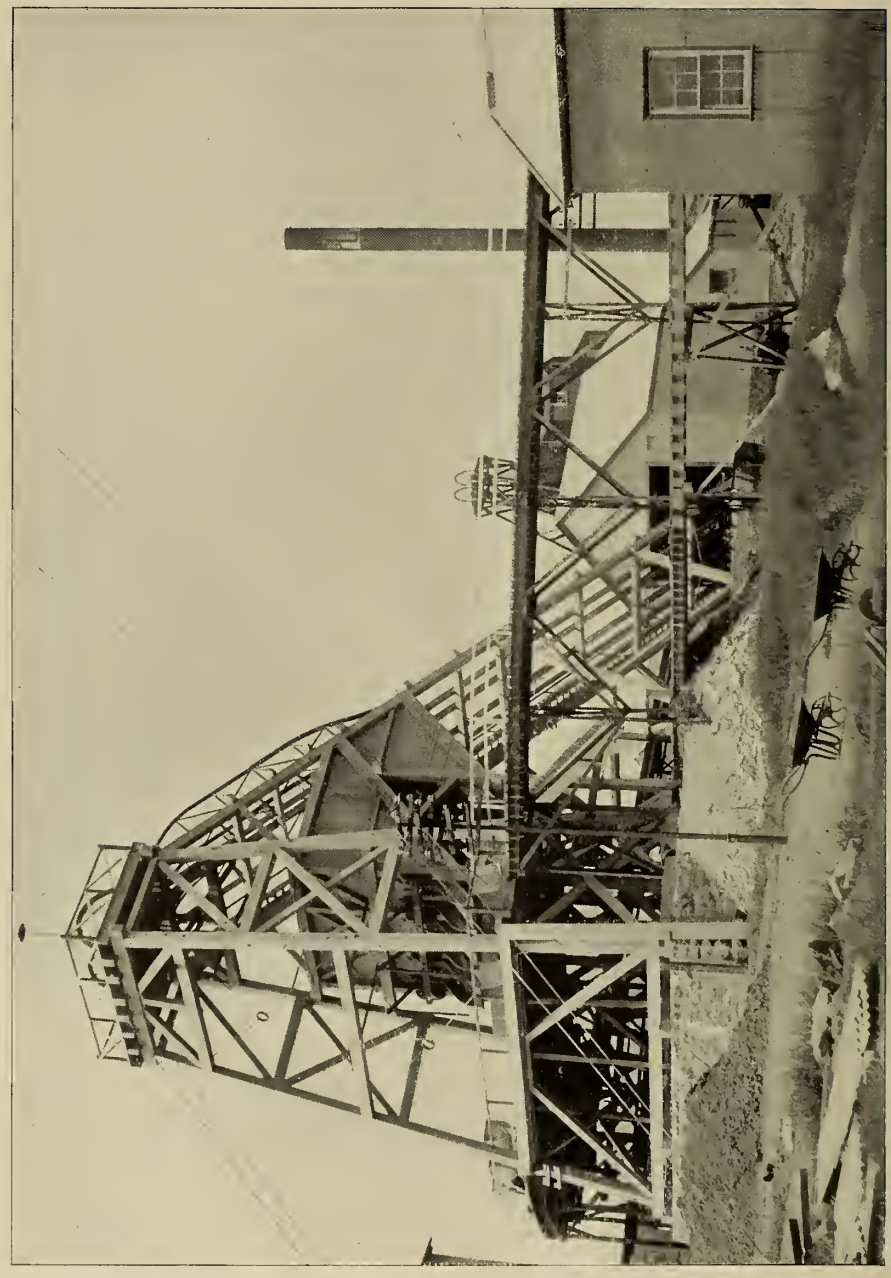
THE CROWN REEF BATTERY.

next, and should make a profit of from 15s. to 20s. per ton of ore milled.

Randfontein is, at present, the end of everything, but probably only for a while. Improved industrial conditions will stimulate prosperity, when it is probable that the reef will be picked up for some distance towards Potchefstroom. Experts in many cases agree that the working of isolated patches of ground along the long line from Randfontein to Klerksdorp is only a question of time.

haps, more upon the factors, reduction of development and operating costs, than upon any others. These, in turn, hang upon the attitude of the government. Should the cost of machinery, dynamite and fuel be brought down to a fair and reasonable basis, it may be roughly stated that the standard of paying propositions would be reduced from 1½ down to 2 dwts. (*i. e.*, from 6s. to 8s. per ton milled), according to the measure of reform effected.



THE EARL CENTRAL GOLD MINING COMPANY'S HEADGEAR.

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Under existing conditions it is very rare for any property yielding an average of less than 5 dwts. of fine gold per ton milled to be making profits. Of course, where working is very cheap, for instance, where the ore body is very wide and where it is possible to run the mill by water power, profits might be shown on a 4 dwt. grade.

The principle of sorting out and discarding the country rock, which has, owing to the thinness of the reef, to be mined with the pay body, is being increasingly adopted on the Rand. To a certain extent, rough sorting is performed underground, and large pieces of country rock are used for making pack walls, etc. In "the early days" it was the practise to get the ore "clean," that is, to leave the "casing" in the mine. Subsequently, however, the American practise of sending everything to the mill was adopted. At the present time one or two mines are reverting to the original plan.

For convenience and facility in sorting, the ore is spread out either on ordinary floors, on circular rotating tables, on travelling belts, or on reciprocating tables. In the case of circular rotating tables, it is customary, in the improved types, to cut out the centre, thus allowing, say, four boys to sort from the inside of the ring, in addition to the half-dozen on the circumference.

A very elaborate sorting plant has recently been brought into use at the Crown Reef. As it is similar to those which have been, and are, being installed at the deep level properties, for instance, the Rose Deep, the Jumpers Deep, the Crown Deep, Durban Roodepoort Deep, and others, it is worthy of detailed description. The table is circular in shape, 25 feet in diameter, and is driven by bevel gearing. Fourteen boys are employed around and about it. The ore, after coming up the shaft, is dumped on to "grizzlies," which screen out about 27 per cent. of the total ore hauled. This proportion (termed "fines") goes direct to the mill. The ore from the bottom of the "grizzlies" is trammed by mechanical haulage to a shoot from which the table is fed. As the table, or ring, travels around, the sorters throw out the barren pieces of rock, which are easily distinguishable.

After completing one revolution on the table, all the country rock has been taken out. Just near the delivery shoot is placed a "plough." As the reef matter comes in contact with this it is thrown off the table on to a "grizzly." This screens out a further proportion of "fines,"—about 18 per cent.,—which forthwith is trammed to the battery. The coarse matter remaining is hoisted by means of an elevator and passed into one of four crushers.

The great advantage following efficient sorting has been generally recognised, and all new schemes include plant to effect this. Put concisely, sorting enables a manager to materially increase the grade of ore sent to the mill at a very small cost. It is needless to crush barren, or practically barren, rock at, say, 6s. to 7s. 6d. per ton, when you can have this discarded at a cost of a few pence.

The writer remembers asking a leading manager whether it would pay to employ white labour for sorting purposes. The reply was, "No. The job suits the disposition of the native, and it would be difficult to get Europeans to do it. The 'boys' soon get to know the difference between good and waste, and we should not obtain a higher efficiency in this regard with white labour."

To a certain, but limited, extent, sorting is practised in the mine—that is to say, the larger pieces of waste are stowed away in the form of pack walls. Of course, by this method, hauling charges are saved; but it will be readily understood that, with the feeble light shed by a candle, it is practicable to sort only a very small proportion of the total rock broken. Ore sorting will, in all probability, form an important factor in the future economical working of the mines of the Rand.

At the "Crown," the "Rose," and other "deeps," double sorting is in operation. It is effected in the following manner. After the rock has

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HEADGEAR OF THE WEMMER GOLD MINING COMPANY.

passed through one revolution of the sorting surface, it is ploughed off into a slide down which it gravitates into crushers. When the ore is passed through a coarse crusher it is screened, the "fines" going direct to the mill. The residues are elevated, re-sorted, and then crushed fine. By crushing as finely as possible it is expected to increase the capacity of the mill.

The double-sorting system is the outcome of experiments made by Mr. L. I. Seymour, consulting mechanical engineer to the Rand Mines. It will be of great interest to watch if the enrichment of the milling grade will prove sufficient compensation for the cost involved, and whether the system will be found superior in all respects to single crushing, which does so much to make Rand companies secure large profits.

In typical surface installations, modern equipments are, speaking in a general manner, similar. One consulting engineer will use Ingersoll compressors, while another prefers the Walker type. In nearly every mill the mortar boxes, stems, tappets, cams, dies, shoes, etc., are of Fraser & Chalmers' make; but in some cases the Sandycroft Foundry Company, Chester, England, has supplied very efficient plant.

Similar variations, of course, are shown in mill and hauling engines, and the principal competing manufacturers are Fraser & Chalmers, of Erith, England, and Chicago; Robey & Co., Ltd., of Lincoln, England; Yates & Thom, Blackburn, England; and Ruston, Proctor & Co., Ltd., of Lincoln, England.

The mines of the Rand group are distinguished by the splendid character of their equipments. As a mine, the Crown Deep, lying, as it does, immediately to the south of such profitable concerns as the Crown Reef, Bonanza and Robinson, is the best of the group. From the two headgears a mechanical haulage outfit connects with the crusher station. The tram road runs up to this on a substantial trestle bridge.

The ore is fed on to a revolving screen, from which it falls on to a 25-foot revolving sorting table. A circular rail is bolted to the table, and this runs upon wheels arranged at convenient distances on the floor. In previously de-

signed plants the wheels were supported underneath the table, but it was found that lumps of rock fell on the rail and caused obstruction. After having been sorted the ore is conveyed in trams to the mill. The battery is of Fraser & Chalmers' manufacture, and the stamps weigh 1150 pounds each. Seymour's clutches are fitted to every ten stamps —*i. e.*, to each couple of mortar boxes.

The mill house measures 203 feet by 75 feet. Adjoining is the engine room, 100 feet by 50 feet. The principal mill engine is a compound of 1000 H. P., and the auxiliary is of about 800 H. P. Both these engines drive on to one shaft, which is divided into two parts. The ends of these have wide flanges, in which eight bolt holes are drilled. A "making-up piece" is provided for insertion between the two ends. Should the large mill engine have to be stopped for repairs, the taper bolts, which go through the flange holes, are taken out, the "making-up piece" is knocked away, and the main engine portion of the shaft is free. The connecting rod of the auxiliary is then coupled up. This little manœuvre can be accomplished in a very short space of time. The engines, as well as the compression plant, take steam from a central boiler station, where there are ten 100-H. P. Fraser & Chalmers "standard" boilers.

From the battery plates and launders the tailings are elevated to the distributing launders. The treatment is upon the double system. There are twelve top and twelve bottom tanks, respectively 41 feet by 7 feet, and 37 feet by 10 feet. The residues are discharged into trams, for which three tracks are under each set of tanks. Slimes are taken off the top tanks by means of rising gates, which are built up as the tanks fill.

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INTERIOR OF THE MAY CONSOLIDATED BATTERY.

The Rand Central Electrical Works, which are situated at Brakpan, East Rand, may, in company with the Rand Central Ore Reduction Works, near Johannesburg, be justly termed the most important undertakings auxiliary to the gold mining industry, if one excepts the railway and the dynamite factory, which

PHOTO BY HOWARD, BOKSBURG.

THE RAND CENTRAL ELECTRIC WORKS.

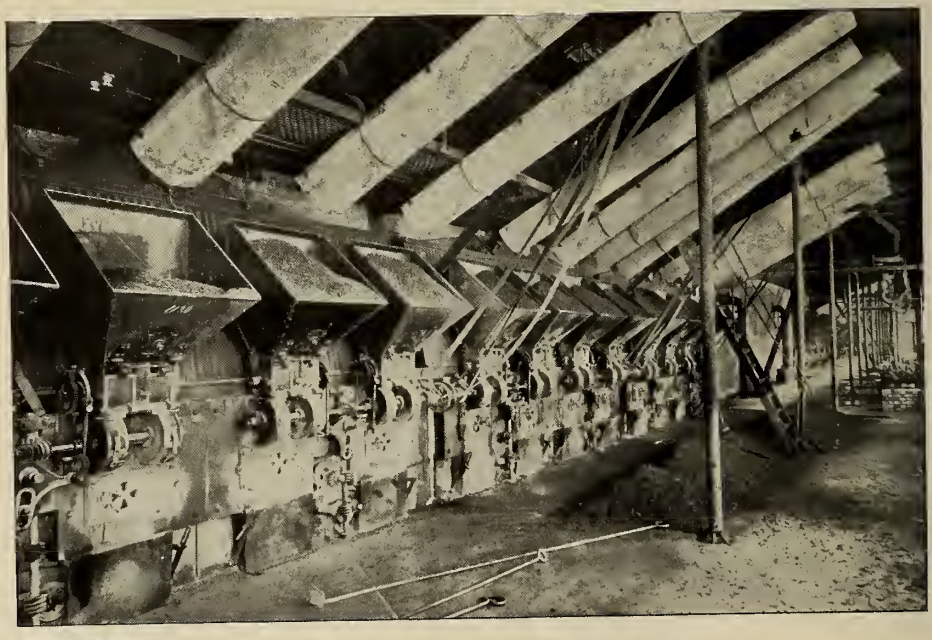

PHOTO BY HOWARD.

THE BOILER ROOM, SHOWING MECHANICAL STOKERS.

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are in quite another category. The electric company was formed about three years ago and cables now extend from the generating station at Brakpan to the Langlaagle Deep, a distance of about 26 miles.

The illustrations on this and the opposite pages will give a good idea of the Brakpan installation. The dynamo room is 200 feet long by 50 feet wide. It contains four 1000 H. P. steam engines of

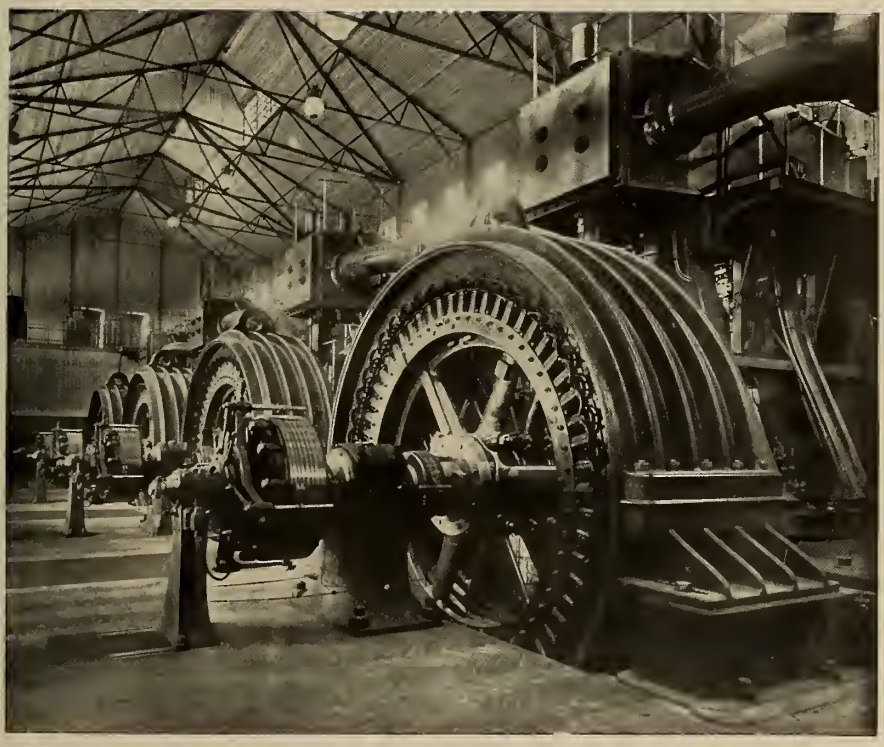

PHOTO BY HOWARD.

A VIEW OF THE DYNAMO ROOM.

triple-expansion marine type, working at 100 revolutions per minute with 180 pounds pressure. The dynamos, which weigh some eighty tons, are directly coupled to the engine shafts.

The current generated is 3-phase alternating of 700 volts pressure. The plant was arranged on the low-tension system so that it would not be dangerous to workmen coming accidentally into contact with the wires. At the gallery at the end of the dynamo room are

step-up transformers which convert the current into one of 10,000 volts. This is conveyed along the line by six copper wires supported on strong steel tube posts made by the Mannesmann Tube Company, Ltd., Landore, South Wales. Lightning arresters at different points protect the line. It is ultimately intended to run batteries by means of the current; but, so far, it is used for pumping, running workshop motors, and haulage. On the whole, thirty-eight motors are now supplied with current, and besides this, lighting work is done at many of the mines. A very important feature of the company's work will be the supply of light to the Johannesburg suburbs and the stations of the Netherlands Railway. The lighting scheme is said to be the largest one in the world.

All the machinery for the Central Works was supplied by the firm of Siemens & Halske, which has done

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TRESTLE WORK TO THE WEMMER GOLD MINING COMPANY'S CYANIDE WORKS.

such great service in the advancement of electrical science. There is room in the present building for a fifth engine, which will doubtless soon be put in hand. If that should not be sufficient, a new station will be erected.

As far as one can see, and provided the company's terms are satisfactory to its customers, there is no limit to the Rand Central's sphere of usefulness. With four engines, profits are being earned, and these should be considerably increased when more power is available. One great point in connection with the company is the low price at which it secures its fuel. "Slack" coal is brought down by gravity from the Transvaal Coal Trust Company's colliery, and thus what is practically a waste product is turned to service.

At the time of writing, the output of the Rand is over 270,000 ounces of gold per month, but before these lines are in print it is likely that an aggregate of 300,000 ounces will have been reached, while a total of three millions of ounces for the year 1897 will also probably have been declared. This achievement is all the more praiseworthy because attained under considerable industrial drawbacks. Three millions is a marvellous result; but what would the world say to five millions? Given the best conditions, there is no reason why that result should not be reached, and even surpassed, not, perhaps, by the Rand alone, but by contributors from the outlying districts, many of which languish for the want of cheapened working conditions.

Nothing has been said, except incidentally, of the geology of the Rand. Truth to tell, in the stirring search for gold geological science falls into a secondary place. Throughout, the governing consideration is practice, not theory.

The potentialities of the Rand have not been dealt with; they have been merely sketched. Given, economic conditions, time will show them in all their magnitude.

WIRE ROPEWAYS.

By W. T. H. Carrington, M. Inst. C. E.

THE transportation of materials by means of overhead wire ropes is now very largely adopted. The original introduction of this system of transport is due to Mr. Charles Hodgson, who, in 1868, obtained the original patent referring to this means of conveyance. It has, indeed, been claimed that a ropeway was in use at Dantzic, Germany, in the year 1696; but as steel wire ropes do not appear to have been invented before the year 1837 this ropeway, about which much mystery exists, must have been worked with hemp rope, and therefore cannot come under the category of wire ropeways. Indeed, so little is known concerning it, that it is perhaps best to ignore it and assume that, to all practical purposes, wire ropeways were introduced by Mr. Charles Hodgson in 1868.

With much prescience, his original patents seemed to cover the principle of nearly all that has been done since in the matter. Where he obtained his first idea of utilising moving ropes for the transportation of loads is not quite clear; but the writer, who was associated with him in the design of ropeways almost from the date of their invention, in a conversation many years ago learned from him that the sight of Hirn's transmission of power by ropes, as exhibited at the Paris Exhibition in 1867, first suggested to him the possibility of slinging loads from the rope and transporting them.

The late Mr. T. Smith also informed the writer that a crude description of ropeway was seen by him many years before the original patents were taken out; but it appears to have been a very primitive and home-made type, inasmuch as it consisted in the tying of bags, containing the workmen's luncheon or dinner, to a travelling rope which was employed for the purpose of hauliug barges through one of those large tunnels which occur on British canals. This, therefore, though certainly a type of wire ropeway for the transport of material, cannot be regarded as a serious anticipation of Hodgson's invention.

The first line constructed under the original patent was an experimental one near Leicester, England, for the carriage of granite, and, as usual in the early youth of mechanical invention, many difficulties had to be surmounted and many problems solved. Probably the remark attributed to George Stephenson's first railway is applicable to this line when, in reply to inquiries of observers as to how the work was getting on, the reply was made that the line "did not get on, it was continually getting off."

This certainly was the case with the rope employed on this ropeway. Nevertheless, to a certain extent, it proved, in the end, a moderately efficient means of transport, and had it not been for the great difficulties which were encountered in dealing with the landowners over whose land the line passed, it is probable that a more permanent and important line would have been erected which would have been at work to the present day. One can sympathise with the objections from landowners to an experimental ropeway passing over their property, with the possibility of their cattle receiving a douche of broken granite from a tumbling bucket failing to pass a pulley on one of the posts, or

A ROPEWAY IN THE ITALIAN ALPS, SHOWING THE LOWER TERMINAL.

because of the constant traffic to the supports to replace the rope in the pulleys, which might even, in time, constitute a right of way. Perhaps it was best that the first experimental ropeway on the running rope principle ceased to exist after some three years' working; but the lessons taught by it were great, and resulted in the excellent examples which are now to be found in all parts of the world.

Charles Hodgson's original patent covered two systems of ropeway,—one in which an endless rope or band was kept in continual motion, and loads, hanging from it, travelled with it; and the other in which fixed rails of wire rope were held in position on which the loads travelled by means of wheels, being drawn by a conveniently arranged hauling rope. The first system seemed, at the time, the most convenient, and was generally adopted in preference to the second

A considerable number of orders followed, especially in the north of France, and, like in many other instances of new machinery, orders flowed in quite too quickly for the manufacturing capacity of the patentee and the experience he had gained. Hence the long list of partial failures which did much to postpone the general adoption of this most useful means of transport, and gave it a bad name. Nevertheless, amongst all these there were many ropeways which, constructed as they were, with crude materials, not perfected by experience, gave good results and fully proved the capacity of the new system of transport under suitable conditions.

It is not surprising that a few years after the original patent of Charles Hodgson was taken out in 1868, American engineers and manufacturers looked about with their native ingenuity to see how they could find a system of ropeway which would accomplish essentially the same results. The immediate outcome of this was the type of ropeway known as the Hallidie system, a particular point of which was that the rope was clipped permanently by a clip from which the load was suspended. This system soon came into use amongst

CABLE TRANSPORTATION IN THE PYRENEES. AN 800-FOOT SPAN CARRYING LOADS OF HALF A TON.

A ROPEWAY IN ALGERIA.

American mining proprietors, and after going through the same period of failure or partial failure that all such inventions must pass through, it became a useful and efficient type of ropeway. Probably, had the same means been taken to spread the system made under the original patent in America that was taken in Great Britain and on the Continent, it would have taken a much greater hold at the time than it did. As a matter of fact, America generally adopted at that time the Hallidie system, Great Britain the Hodgson system and the Continent, for a long time, the same.

The demand for ropeways was obviously too great for one manufacturer to meet, and Germany, in the person of Mr. Bleichert, looked around for some system which they could adopt, and, rightly or wrongly, call their own. He took up the fixed rope system with endless hauling rope, included in the original ropeway patent, but not at that time worked out in that country. With certain improvements in detail he placed this system before the public, and in conjunction with other German manufacturers, is now a well-known advocate of this type of ropeway.

The question thus became, not which was the best type of ropeway for the position, but which manufacturer should we employ to make the ropeway. Therefore, in America we find the greater number made on the Hallidie system, in Great Britain and her colonies those on the Hodgson system, and in Germany and on the European Continent generally, the fixed-rope system, called the Bleichert system. From this sprang much trouble and much to retard the adoption of the ropeway system, and respecting this the writer would point out that it is only reasonable that each type of ropeway should be made for the situation in which ropeway has to be used. It would be just as suitable to take a locomotive designed for railway service and put it to work at a mine, as to take one type of ropeway and put it to work in a place for which another type of ropeway is most suitable. The writer has met with a large measure of success in the design and application of ropeways by refraining to tie himself to one particular system, but by applying to each particular situation the type of ropeway most suitable.

Many of the failures that one hears of respecting ropeways arise from the fact that a system has been put in which is totally unsuitable for the work that it has to do, simply because the manufacturer who has secured the confidence of the purchasers makes only one system, and therefore has supplied this one.

As regards the applicability of each system, without going into details of construction, it may be stated generally that the running-rope system, commonly known as the Hodgson & Car-

rington system, originally patented by Mr. Hodgson, and much improved in detail by the writer, is suitable where the quantity to be carried does not exceed 400 or 500 tons per 10 hours, where the inclines do not exceed 1 in 3, and where the individual loads do not exceed 6 cwts., and also where the topography does not necessitate spans of greater length than 600 feet. Longer spans, steeper inclines, greater quantities, and heavier loads can be carried by this system, but not so advantageously, in the writer's opinion, as by another system, referred to hereafter. Examples of this type of line are shown in the illustrations accompanying this article, and it may be generally said that there are about 400 miles of this type at work in various parts of the world.

The Hallidie system, which is merely an adaptation of the endless rope system, patented under the original wire ropeway patent, but modified in some details by an American inventor, is most suitable where very steep inclines, and sudden and continual changes of level have to be operated over. It is probably impossible to state the limit of incline on which this type of ropeway can work. As guard or depressing-pulleys may be placed wherever necessary without obstructing the passage of the carriers, the vertical angle of the line may change at each post.

The fixed rope system, being that chiefly introduced on the European Continent, is especially suitable where the quantities to be transported exceed 500 tons per day, except in the case where grouped lines of the first type are suitable, and where the loads exceed 6 cwt.; also where inclines exceed 1 in 2 or 3, and where spans are over 600 to 1000 feet.

The system in which a single rope is used, is a system introduced by the writer to meet special requirements which he has found very suitable for application in many districts, notably at Cape Town and Hong Kong, for example, and is specially applicable where moderate quantities have to be transported. For heavy individual loads, and great spans and steep inclines, it is cheaper in first cost and maintenance than the third type, and simpler to erect and to manipulate.

There remains one other system which, while certainly a ropeway, is not by any means new, and has probably been used in some form or another for very many years preceding the invention of wire ropeways by Hodgson. This is most suitably used where the quantity is not sufficient to justify the use of the fixed-rope type, and also where the spans are extremely long and great simplicity of detail is desirable.

THE DRIVING TERMINUS.

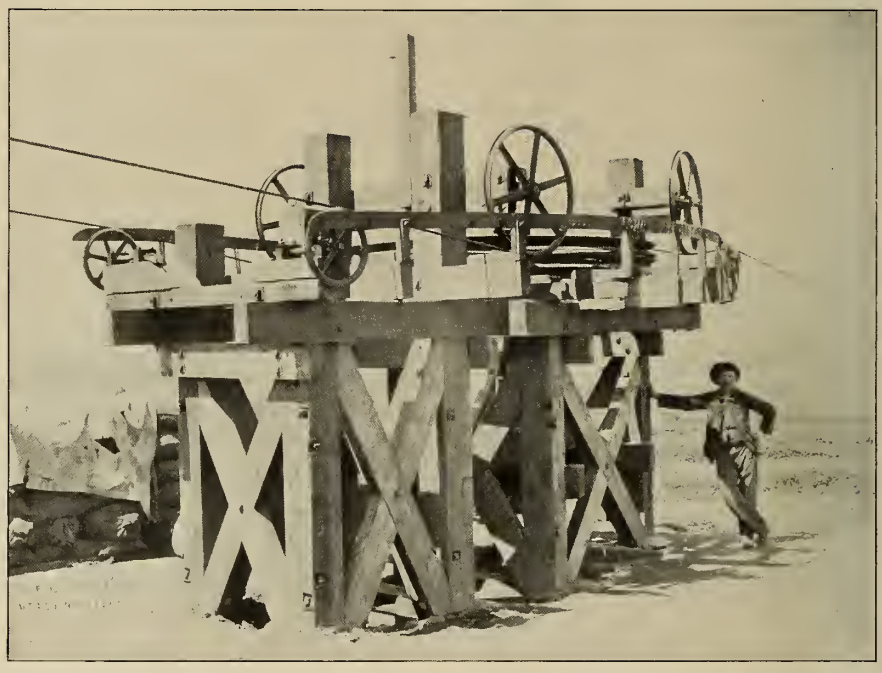
These five systems represent generally the types of ropeway now in use, and, as before stated, were, with the exception of the last two, described in the original patent for ropeways in 1868.

The last two types, viz., the fixed-rope and double fixed-rope systems,

working by gravity, have been introduced on a large scale by the writer and have proved to be most efficient means of transport. The illustrations given in this article show all these different types and give some idea of the magnitude of the work which has been executed in conjunction with this system of transport of material.

Shortly after the early introduction of ropeways, inquiries concerning them poured in from all parts of the world. Many of them were curious. A man choked off at the first intimation as to what the cost of such an apparatus would be.

Cost has always been a stumbling-block with those desiring to purchase a wire ropeway and who seem to expect them to be supplied at an exceedingly cheap rate. Exceedingly cheap a ropeway cannot be. To be efficient it must be constructed of the best materials throughout and must be of the best design, but compared with a railway, ascending a steep incline and crossing a



ARRANGEMENT OF ANGLE AND INTERMEDIATE DISCHARGING POINT IN AN ALGERIAN ROPEWAY.

from India required an outfit so that he might travel comfortably in a carrier suspended in the air from a ropeway and shoot tigers without risk of damage to himself. Another correspondent from India required the supports to be made of abnormal strength because the elephants which infested the part through which the ropeway had to pass would, undoubtedly, if possible, pull them down. Many other curious stipulations and proposals were made, some seriously, while others, no doubt, were

deep ravine or broken country or bottomless morass, undoubtedly a ropeway shows its economy both in first cost and in working.

The type of ropeway in which two fixed ropes are carried on a steep angle, generally spanning a wide space, probably from the top of a mountain to the plain below, is well worth notice. On each rope is placed one carrier arranged so that when it is loaded and allowed to descend it draws up, by means of the hauling rope, another carrier from the

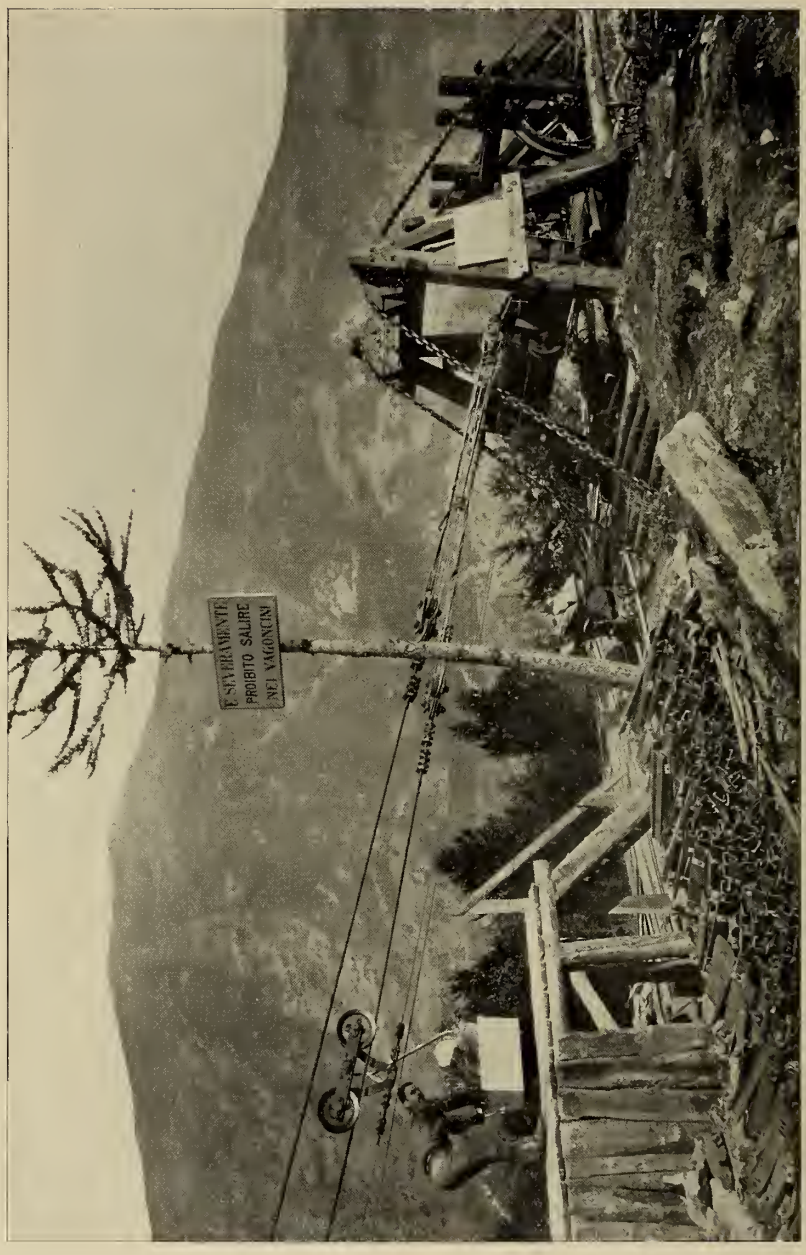
AT THE HEAD OF A STEEP DESCENT IN THE ITALIAN ALPS.

lower end. In this way, by loading each carrier in turn, materials can be transported with safety from the top to the bottom of a mountain.

The writer has introduced sundry details into this type of ropeway, especially as regards the machinery for controlling it, and the introduction of supports for enabling it to pass, not only over wide spans, but also over rugged country on which supports can be introduced. The production of high-strain steel wire has enabled this type of ropeway to be used for exceedingly long unsupported spans. A few years ago the writer designed and carried out the erection of such a ropeway for a span of over 1500 yards without a support, and has lately undertaken, in conjunction with Messrs. Bullivant & Co., Limited, of London, contractors for this class of work, to construct one having a still longer span,—2000 yards,—without a support. Without the splendid high-class steel wire which is now produced, having a breaking strain of 130 tons per square inch, such schemes would be impossible.

Another example of this type of ropeway is erected at some mines near Pierrite, in the south of France, near the high road to a fashionable watering-place at Cauterets. Its prominent position has attracted many interested observers, and amongst those who obtained permission from the director of the mine to make use of the ropeway to ascend to a higher level have been the late Lord Randolph Churchill and Madame Sarah Bernhardt. The latter expressed herself exceedingly gratified at having found some new source of enjoyment for which she had searched in vain. The delight, she said, of leaving the earth for a short time, and travelling rapidly into space, was worth a visit to the south of France.

Respecting the application of these ropeways, there is apparently hardly any part of the world where they may not be seen. From the snow-clad mountains of Iceland to the sunny sugar-cane fields of Mauritius they are always in evidence. In the land of the newest of coming powers,—Japan,—many are to be found, and while mentioning this country it may be well to state the great aptitude that the Japa-



ANOTHER ROPEWAY IN THE ITALIAN ALPS, SHOWING A DISCHARGING TERMINAL.

nese have shown in the erection of such work. The writer had under his charge, on account of Messrs. Bullivant & Co., the contractors, several ropeways of an unusually complicated character, and by sending out instructions, and, of course, the necessary working drawings, the Japanese themselves, without any outside help, erected the plants and set them to work in a manner which was altogether admirable.

Passing to India, where the great work of the century, the construction of the Periyar dam, was effected, to enable the waters of the river on the west side of India to be passed through the backbone range of mountains and delivered to the thirsty east side for irrigation purposes, two of these ropeways were employed, and in the case of one of these special instructions were given that the supports should be made of unusual strength to resist the inroads of elephants. In Australia and New Zealand, too, many of these ropeways are to be found.

In the island of Mauritius, Messrs. Bullivant & Co. have supplied no less than 60 miles of such ropeway for the carriage of sugar cane, taking the place of oxen previously employed, which failed in their work owing to the prevalence of the foot and mouth disease.

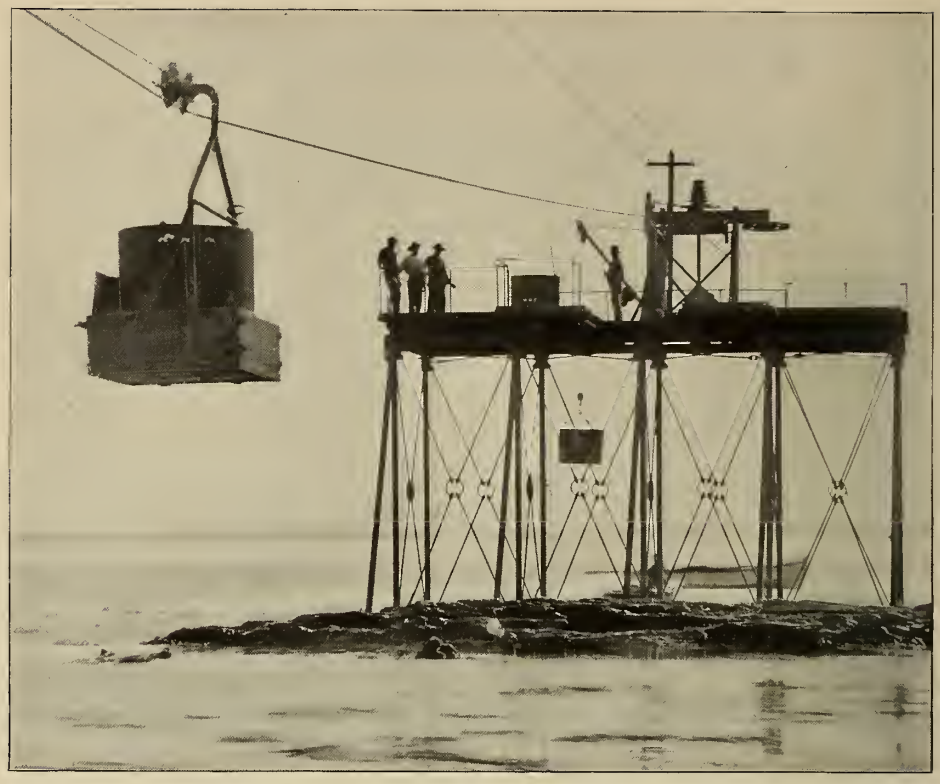
In Africa we find near Cape Town a most remarkable type of ropeway, constructed by the same firm from the designs of the writer. Owing to a threatened water famine at Cape Town the corporation wisely decided to construct a reservoir in the higher level near Table Mountain. So inaccessible was the spot for the materials required for the work that it was necessary to have a ropeway to convey them from the level of the sea. The illustration on this page shows this installation, which was constructed on the single-rope system, in which only one carrier is employed which is run to and fro on the one rope by means of an endless hauling rope. It will be seen how this line, approaching the mountain on a rough plain, suddenly leaves the level, and, spanning a wide hollow to a peak on the side of the mountain, rests for a short distance, and with another long span arrives at the terminal at a great height above the starting point. This line, constructed for the carriage of bricks and mortar, was considered so efficient and safe as to justify the Mayor and Corporation of Cape Town ascending it for the purpose of an official visit to the works.

A much humbler and equally useful ropeway has been constructed in the same district for the carriage of cray fish from fishing boats to the factory where they are canned and prepared for the Paris market. This industry is a large one, carried on under French direction.

A SOUTH AFRICAN INSTALLATION SHOWING A CARRIER IN TRANSIT ON A LONG SPAN WITH STEEP INCLINE.

The cray fish are brought as near to the shore as possible, to a point where an iron sea staging is erected and fixed solidly into the rock. From this point to the shore one of the above-named single-rope arrangement is stretched, and a carrier, holding 8 cwt., makes from 27 to 30 trips per hour. A crane, employed for the lifting of the fish from the boats, is operated by the rope which moves the carrier on the ropeway.

Following round the coast we come to some small ropeways in use for the



A PLANT IN SOUTH AFRICA, SHOWING A STAGING ERECTED IN THE SEA AT WHICH SHIPS DISCHARGE AND WHICH IS CONNECTED WITH THE SHORE BY MEANS OF A ROPEWAY CAPABLE OF TRANSPORTING 10 CWT. AT A TIME.

construction of railways on the west coast of Africa. A wire ropeway of simple form was suggested by Mr. W. Shelford, M. Inst. C. E., for the purpose of moving materials for the construction of railways over ravines by hand power. These have been put to use and have proved most efficient adjuncts to the construction work.

At Cape Verde island a ropeway has been used for the last twenty-two years for the carriage of coal in conjunction with Messrs. Cory's well-known coal depot, where large numbers of steamers are coaled during the course of a year. This line carries about 200 tons per day, and by the motion of the rope operates a crane on the pier which lifts the coal from the ships which bring it from England.

In South America ropeways are to be found in abundance in Chili, Bolivia, Peru, Brazil, and in Central America as well, while in the United States, as might be expected from a go-ahead nation, all types of ropeway are in use for many and divers purposes.

In Spain, at the port of Bilbao, the great iron mining centre, no less than 25 to 30 ropeways are occupied in bringing down iron ore from the high level on which the mines are situated to the railway leading to the river where the steamers are loaded. Both the running-rope system and the fixed-rope system are employed, but the number of the former greatly exceeds the latter. One can suppose only that "the survival of the fittest" can account for this.

In other parts of Spain, too, many ropeways may be found. In France there are perhaps not so many as in other parts of the world, though the

writer has had the task of designing more than ten for this country and its dependencies.

In Great Britain comparatively small use has been made of ropeways. This is due almost entirely to the difficulty of getting way leave. Everybody over whose land a ropeway passes expects to make something out of it, and generally expects to make too much, or at least more than such an enterprise can afford to pay. The result, of course, is that none of the ropeways are of considerable length. Most of them are made for use in factories, and are not more than a mile long. They are, however, very interesting in themselves.

Many manufacturers in Lancashire and Yorkshire have their own coal mines and in many cases ropeways are employed for the transport of coal from the mouth of the mine direct into the boiler house, where it is tipped into bins from which the mechanical stokers, now so generally used, are automatically fed. In some cases materials such as velvets and high-class fabrics, are transported from one building of a factory to another by means of this system, which admits of a direct communication, passing over the lower buildings which may be between the points of departure and arrival. The convenience of promptly transporting materials from a workshop where one process is carried on to one where the next process is in operation cannot be over-rated.

An interesting example of a short ropeway is that constructed many years ago at Purfleet for the carriage of gunpowder. In this case the exigencies of the traffic required that gun metal should largely replace iron in the construction. Barrels of gunpowder weighing 1 cwt. and upwards are transported to an examining house situated at a safe distance from the magazines. There the powder is examined after return from use at foreign stations. It is repacked and returned to the magazines without touching the intermediate ground at all.

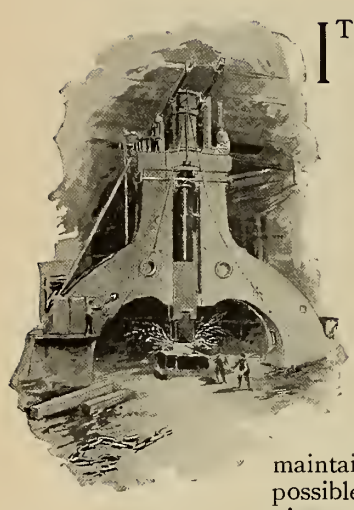
That the transport of materials by ropeways can be done safely is proved beyond all question by the success of this installation. If there was any doubt on this subject, reference might be made to the number of ropeways in factories transporting materials over weaving sheds, the roofs of which are generally composed of glass and under which numbers of men and women are employed.

In the north of England a ropeway was for many years at work, until the dismantlement of the works, which had served for the carriage of material at the rate of 300 tons per day from the centre of an enormous chemical works over a public street, in a town on the banks of the river Tyne, to a terminal placed on the edge of that river, from which the material was discharged into ships lying alongside.

That this manner of transport has a great future before it, none who are acquainted with it can doubt. Much of the prejudice which is always found to exist against a new thing is vanishing. That such prejudice is real is beyond all question, and is well illustrated by the fact that if ever a ropeway is erected, even at the present day, the wiseacres of the district in conversation about it, without one exception, prophesy its failure and refer to it in derogatory terms, calling it a trapeze or a telegraph wire. As usual, such prophets are always wrong, and the results soon prove that a ropeway, though it has some resemblance to a telegraph wire, is capable of doing very real and efficient work, and of operating over sections of ground with which no other known system could begin to cope.

NICKEL STEEL ARMOUR IN THE UNITED STATES.

By Titus Ulke, E. M.



IT is a well known fact that a large number of methods of preparing armour plates have been patented, and that only very few of these are in actual use. Details of the methods employed are not readily obtainable, owing to the secrecy regarding them which is being maintained, and it is not possible, therefore, to give more than a general description of the actual practice of treating nickel steel in making armour.

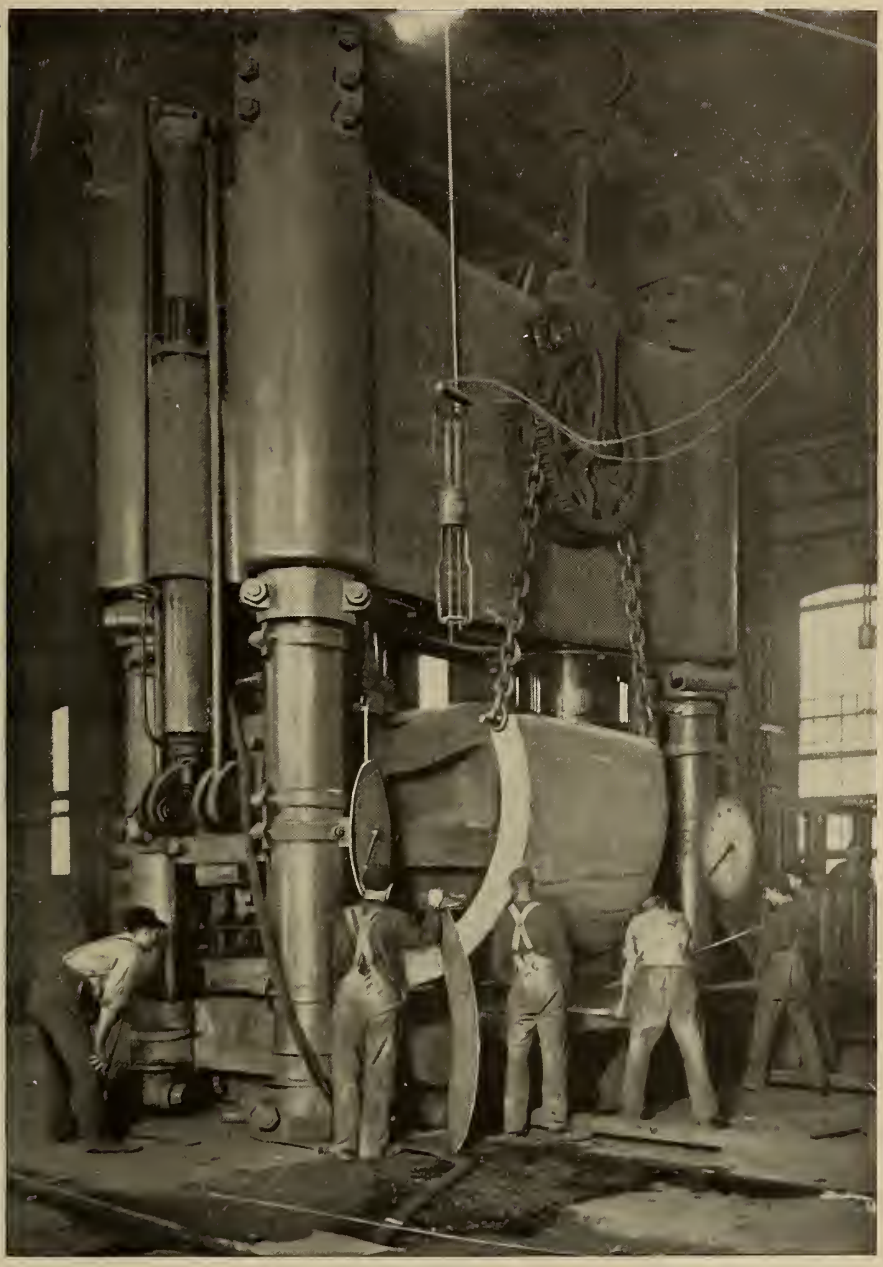
The trials which first demonstrated the superiority of plates of nickel steel over simple and compound plates of plain steel were made in 1889, under the direction of B. F. Tracy, then Secretary of the United States Navy. As a result of these experiments, nickel steel was adopted by the United States Government for the armour of its warships, and Great Britain and France soon followed.

In the United States, the nickel steel, produced in a basic-lined, open-hearth furnace, is generally cast into ingots and forged or rolled into plates of specified dimensions and shapes, a common size being about 16 feet long, 8 feet wide and from 6 to 18 inches thick. Each plate is then lifted upon a movable hearth, carried by a truck, or upon a fixed hearth of a heating furnace with removable walls or roof, and prepared for the subsequent operation of "Harveyising" or "supercarbonisation."

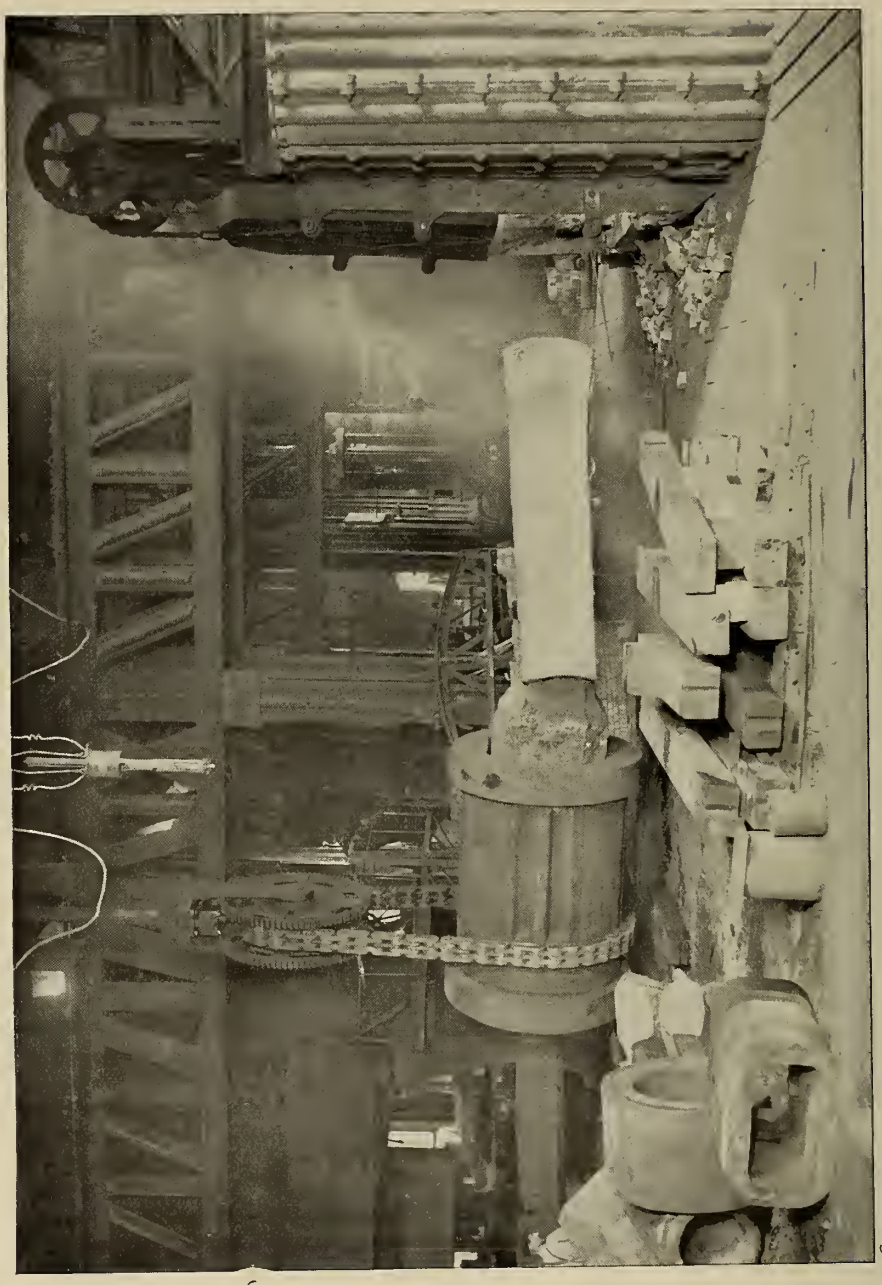
In the Harvey process, the plate is inclosed between a mass of noncarbonaceous material, such as sand, on one side and a mass of granular carbonaceous material, preferably charcoal, on the other side, all contained in a fire-brick compartment formed within the heating chamber of the furnace. This heating chamber is then maintained for a predetermined period of time at a temperature above the melting point of cast iron, although so high a temperature is not believed to be essential. The duration of the heating varies from 5 to 27 days, according to the depth and degree of supercarbonisation required. After the conclusion of the carburising treatment, the plate is taken out of the furnace, and, without removal of the carbonaceous material from its surface, is allowed to cool down to the proper temperature for special chilling and hardening. During the cooling, the carbonaceous material protects the hot supercarbonised surface from the air, and thus prevents the formation of scale, which, if present, would interfere with the subsequent hardening of the metal beneath it.

When the surface has finally cooled down so as to have a dull cherry-red color, as determined by testing, the carbonaceous material is quickly removed and the plate is rapidly chilled and hardened by simple immersion in very cold water, or by being thoroughly sprayed with it for perhaps several hours. A stratum of steel of prescribed thickness upon the side of the plate with which the carbonaceous material has been in contact is thus made to acquire a condition of excessive hardness upon its exposed surface and a condition of gradually diminishing hardness as the depth from this surface increases.

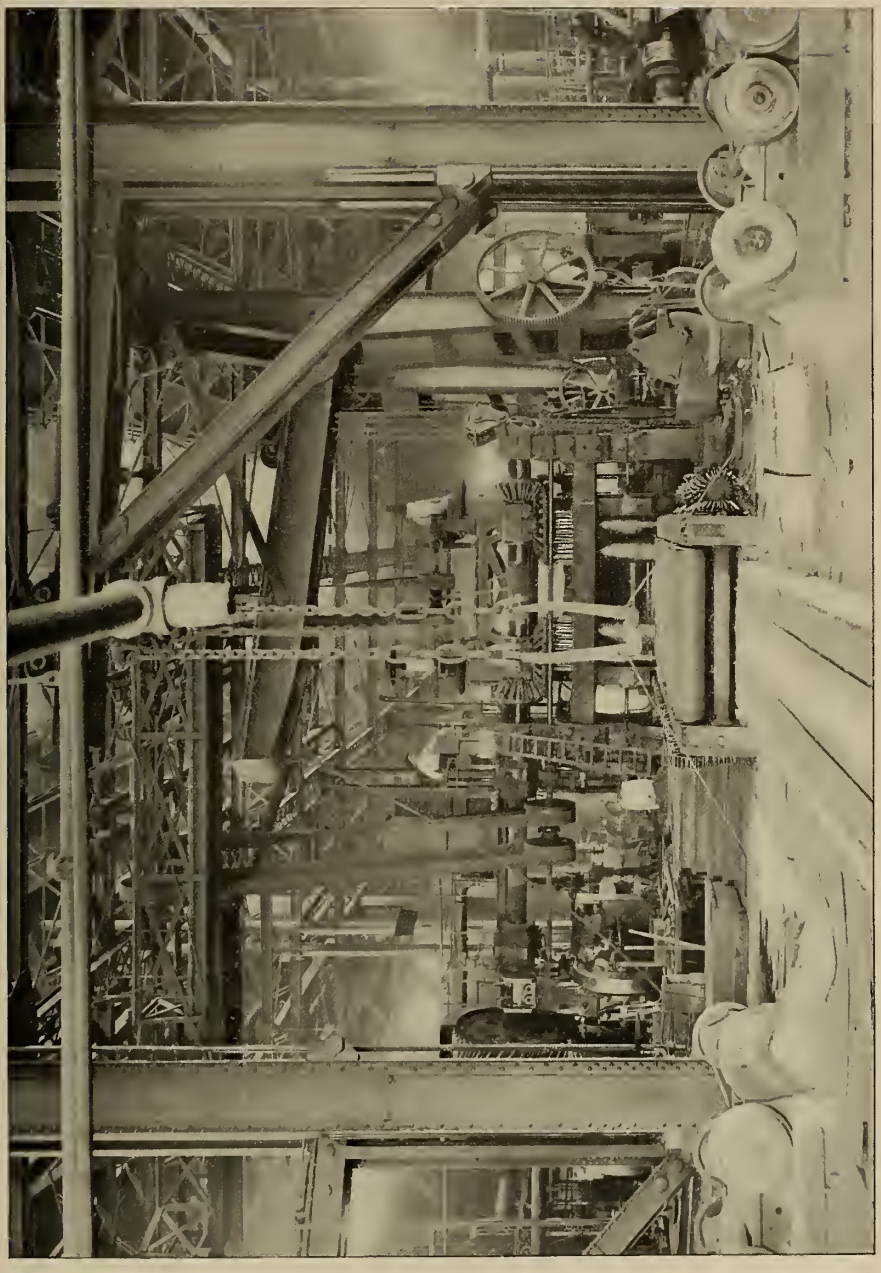
The length of time required for the operation of supercarbonisation can be



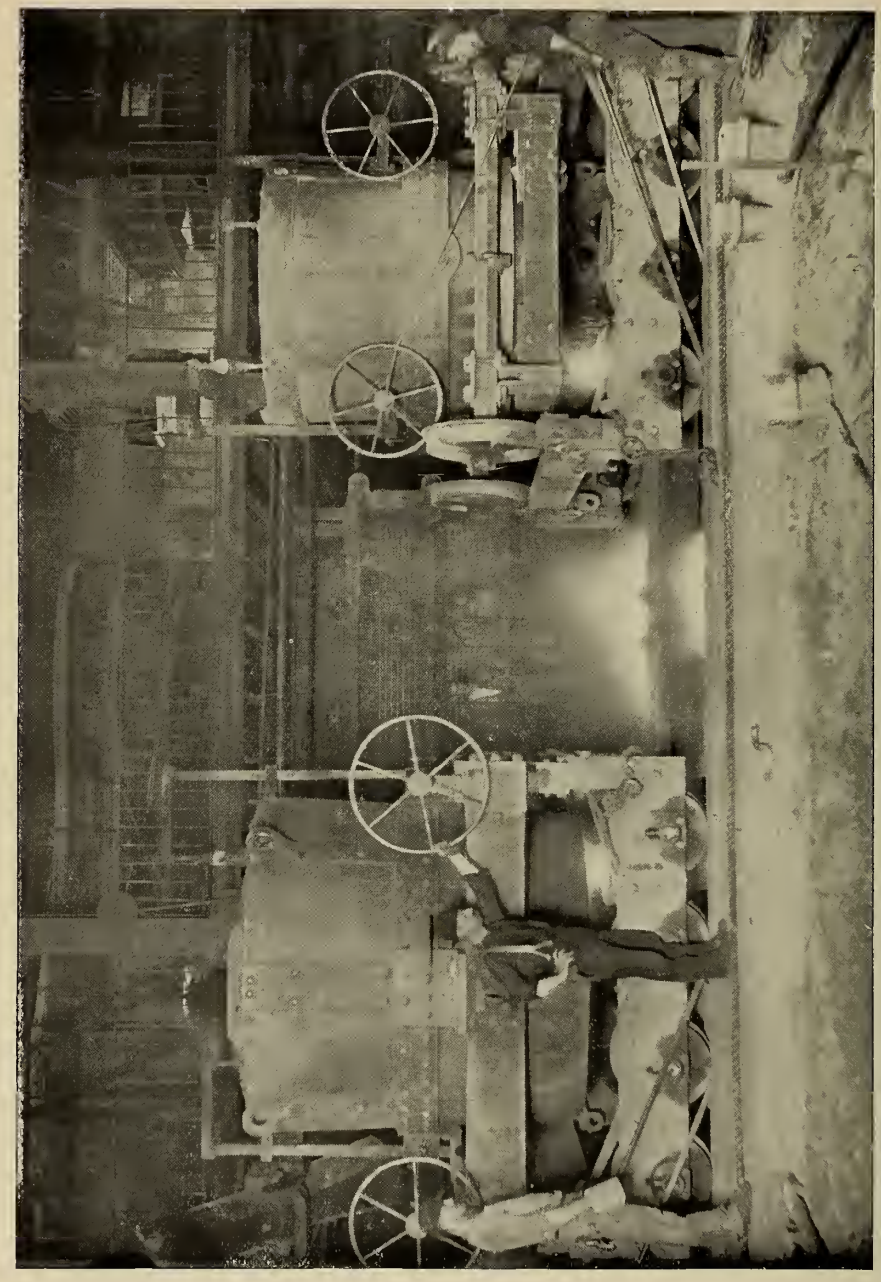
THE 7000-TON PRESS AT SOUTH BETHLEHEM, BENDING AN 8-INCH NICKEL STEEL PLATE FOR THE TURRET ARMOUR OF THE U. S. BATTLESHIP "MAINE."



A 75-TON NICKEL STEEL INGOT COMING FROM THE HEATING FURNACE AT THE BETHLEHEM WORKS.



THE ARMOUR PLATE ROLLING MILL AT THE HOMESTEAD WORKS OF THE CARNEGIE STEEL CO., LTD.



CASTING AN 80-TON ARMOUR PLATE INGOT AT OPEN HEARTH FURNACES, AT SOUTH BETHLEHEM.

considerably shortened by substituting hydro-carbon gas, such as acetylene, illuminating gas and petroleum vapour for the charcoal or coke commonly used to supply carbon to the plate. This cementation or supercarbonisation of armour plate by means of gas, as well as the apparatus necessary, has formed the subject matter of numerous United States patents. One of the most important of these, granted in 1895, to Schmitz & Ehrenberger, was assigned to the firm of Friedrich Krupp, of Essen, Germany, whose rights in the United States have recently been purchased, it is said, by the Carnegie Steel Company. Other important patents on cementation by means of gas were granted to H. Schneider, of the Creusot Works, in France, and to Slocum & Corey, of Pittsburg, Pa.

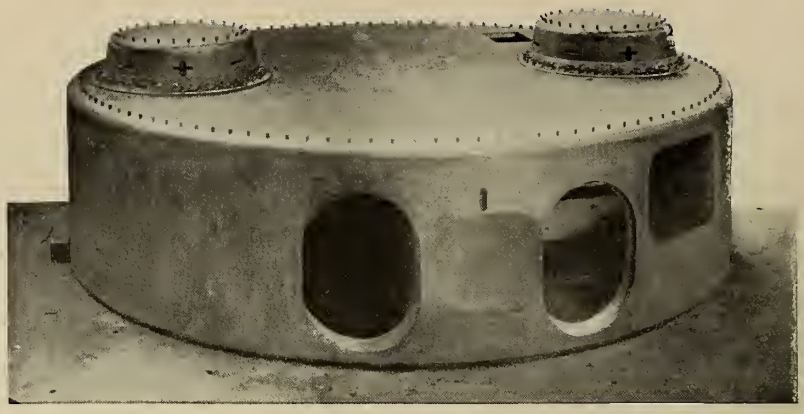
Another important improvement in the method of making armour plate was inaugurated by William Corey, of Pittsburg, who received a patent in 1895, on a process for subjecting the plate, while heated to a temperature below 2000° F., to an extreme compression, without producing more than a slight elongation of the plates, this compression being substantially uniform throughout its area. Corey, who assigned his patent rights to the Carnegie Steel Company, states that the result of subjecting the plate to the usual supercarbonising treatment is to change the semi-fibrous character of the body of the plate produced by the previous working and to convert it into a coarse crystalline condition, thus impairing the main mass while hardening its surface. This weakened condition of the plate, which had heretofore been inherent in supercarbonised steel plates, is entirely removed by Corey's process. The compression not only restores to the metal its forged characteristics, but also adds increased strength, density and toughness to it by reason of the low heat employed.

Before commencing this operation, however, it is preferable to test the plates by drilling a few holes in each one, and analysing the drillings at different depths to ascertain the depth and degree of carbonisation. The plates are then heated to about 1600° F., or to a temperature sufficiently high to permit the metal to be compressed, but below 2000° F., or below the temperature proper for ordinary elongation and reduction of the metal in rolling. This heating takes from ten to twenty hours, according to the size of the plate. The latter is then taken to the compressing machine,—a hydraulic press or a hammer. The use of rolls is not desirable, as under them the metal will elongate and its body will not become condensed as when the press is employed.

The dies of the press, both upper and lower, are made as long as the plate of steel is wide, and with comparatively narrow faces, say, from ten to twelve inches wide. If the faces of the dies are too wide, the plate would have to be at a higher temperature, so as to secure the desired degree of compression; and a temperature as low as is compatible with that result is desired, as stated above, in order to prevent decarbonisation of the plate, and also to secure the condensing and compacting effect of the pressure applied, instead of a spreading or elongating of the steel, which would be the consequence if the metal were too hot.

When a hydraulic press is used which is capable of exerting a pressure of about ten and a half tons to the square inch of surface, an armour plate, of the dimensions before stated, may be readily reduced an inch in thickness by each first stroke of the upper compressing die. The plate is moved forward between the dies after each stroke until the entire surface has been acted on. This operation is repeated, moving the plate back and forth, until sufficient compression is secured.

Practise has demonstrated that upon thus compressing a nickel steel armour plate sixteen feet long, eight feet wide, and seventeen inches thick, with a hydraulic press capable of exerting a compression of about ten tons per square inch, so as to reduce the plate to a thickness of fourteen inches, the plate elongates only about thirty inches, more or less, and does not perceptibly expand laterally. After the plate has



A COMPLETE 8-INCH GUN TURRET FOR THE U. S. BATTLESHIP "MASSACHUSETTS," MADE AT THE CARNEGIE CO.'S HOMESTEAD WORKS, PITTSBURG.

thus been toughened and compacted by pressure, it is annealed. For this purpose, it is reheated in the furnace during a period of about twelve hours, up to about 1350° F. The heat is then withdrawn, and the plate is allowed to remain in the furnace for about forty-eight hours while slowly cooling.

During the reheating for annealing, the supercarbonised portion of the plate is protected from oxidation by a light covering of carbonaceous matter, which, in turn, may be protected by some suitable refractory substance.

When sufficiently cool after annealing and before tempering, the plate may, if desired, be again tested to ascertain whether it is sufficiently carbonised. It is then strengthened by a forging press, or otherwise, and is machined to the required dimensions, the necessary allowance being made for contraction during the subsequent tempering, which is the last step of the process.

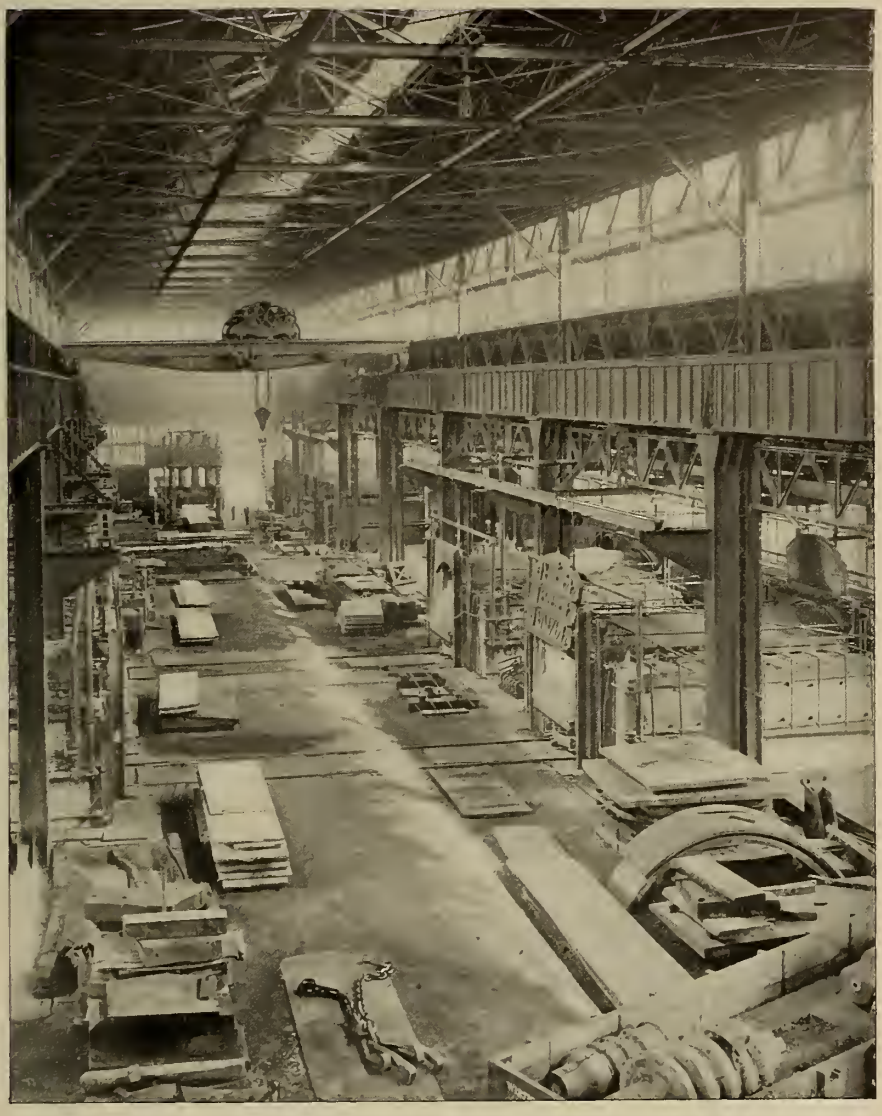
In this operation of tempering, the plate is again slowly heated in the furnace to about 1350° F., the precautions before employed to prevent oxidation of the surface being repeated. Any scale or other matter, adhering to the carbonised surface of the plate, is carefully removed, before and after reheating, by wire brooms, or, if necessary, by hand hammering. The reheated plate is hardened by means of cold water, which may be conveniently applied to the plate in a horizontal position on an open framework, between a series of nozzles above and below the plate, which spray copious jets of cold water upon it. This is continued until the plate is sufficiently cooled, say, to a temperature of 100° F. This completes the operation, excepting that if the plate has become misshapen by the water-cooling, it is reheated to a low temperature, say, 200° F., sufficient to permit of its being rectified in shape by the hydraulic press or otherwise.

The protecting of the plates, whenever they are subjected to heat, with a coating of carbonaceous matter, and a superimposed layer of finely divided refractory substance, is very important, owing to the excessive scaling or surface oxidation, to which nickel steel is subject.

The advantages of Corey's invention are apparent, since the character of the metal which has been impaired by the supercarbonising step is not only restored to its former texture, but is condensed and its strength materially increased, thus combining the advantages of a plate having a carbonised face with those of a non-carbonised, but forged, plate having the stronger character peculiar to forged metal. Steel plates treated as here described have shown a tensile strength about 12 per cent. greater, and an elongation about 15 per cent. greater than non-compressed plates.

It may not be uninteresting to observe

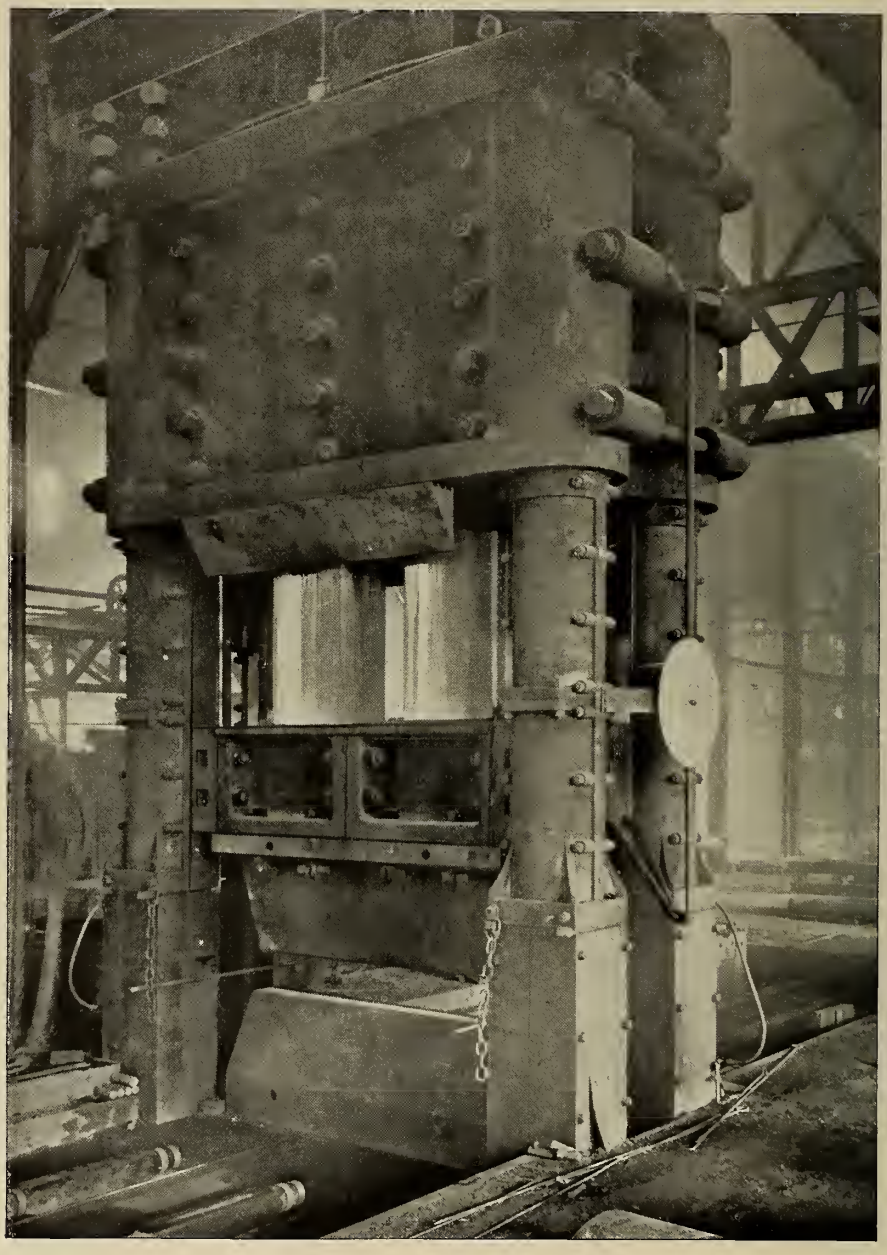
that the cutting and drilling of the plates, after they have been hardened, is greatly facilitated by heating the part of the hardened face to be cut or drilled by means of an electric arc. More detention to the excellent Whitworth method of fluid compressing open-hearth steel for heavy forgings, as used at the works of the Bethlehem Iron Company, at South Bethlehem, Pa.,



THE ARMOUR PLATE PRESS SHOP AT THE HOMESTEAD WORKS OF THE CARNEGIE STEEL CO., LTD.

tailed reference to this has been made in an article in this magazine for March, 1897.

In concluding this outline of American practise, it may be well to call attand to state that the reason the Bethlehem Company does not fluid compress armour plate ingots, is that these are usually rectangular in form, and a mould of that shape would not



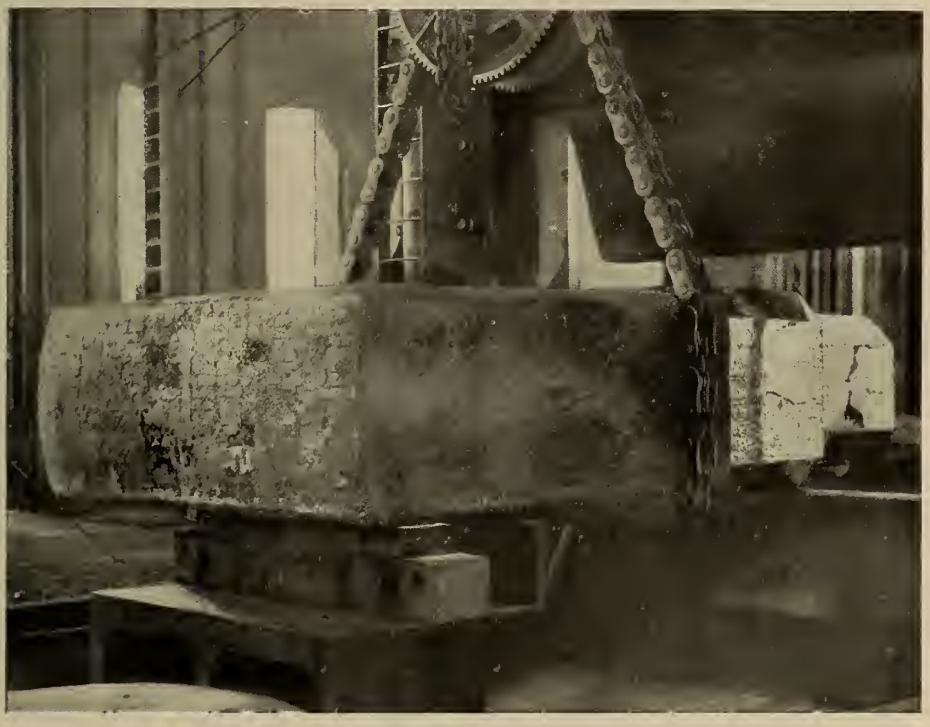
THE 14,000-TON HYDRAULIC FORGING PRESS AT THE BETHLEHEM WORKS.

resist the enormous pressure required by the fluid compression process.

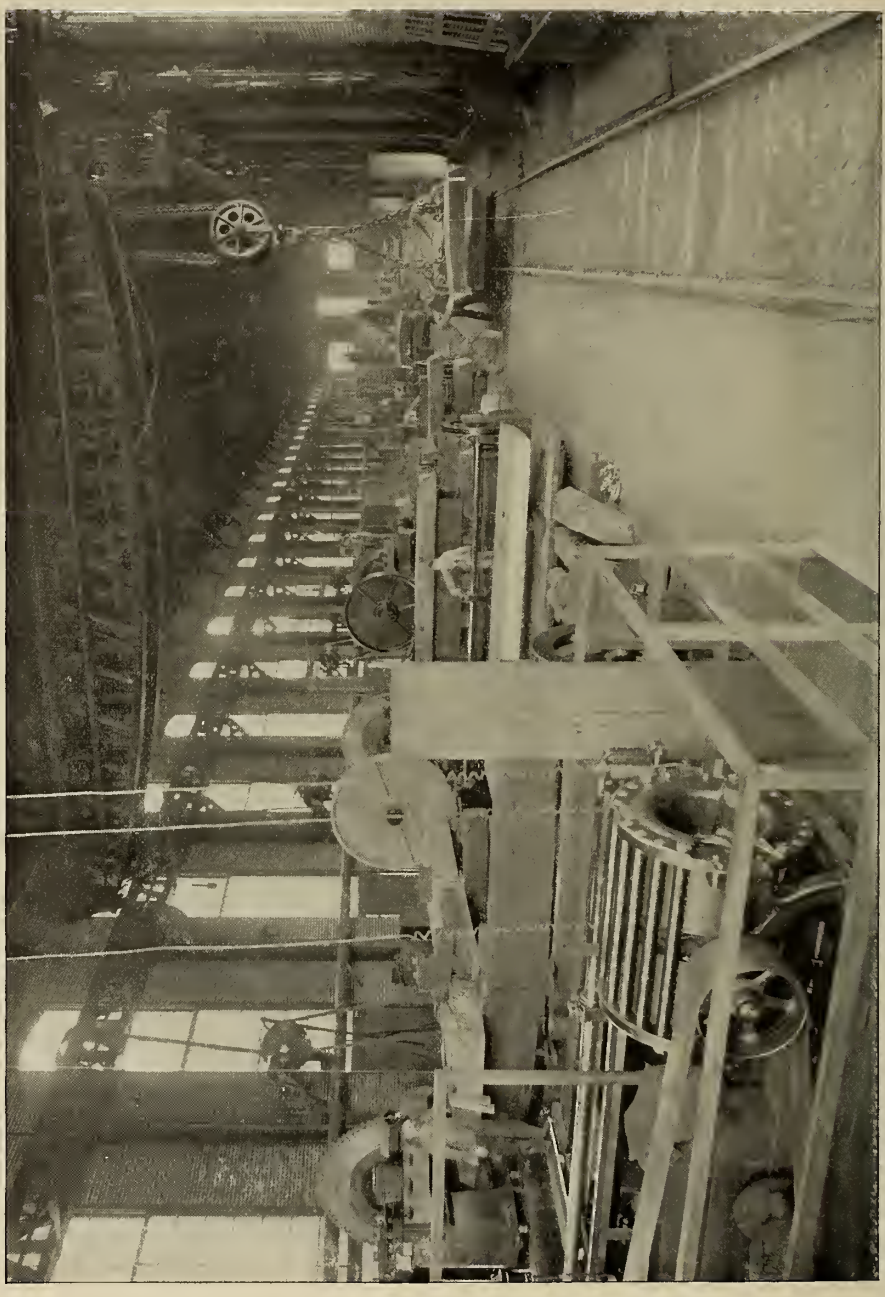
Experience gained by courageous enterprise has finally solved, one after another, all the problems which the manufacture of the hardest, toughest and heaviest armour involved, such as the difficulties and risks of combining large quantities of molten steel, fused in separate furnaces, and casting ingots of 50 to 100 tons in weight, the danger of lack of uniformity of such immense masses of metal, and the occurrence of internal defects and of cracking in cooling, in reheating and in working, and finally, the design and construction of suitable appliances for handling, forging, rolling and shaping the plates, and of machine tools for subsequently trimming them to final shape.

But this experience has cost considerable sums. For example, it has been stated that $500,000 was paid by the Bethlehem Company to Le Creusot Company, of France, merely for the supply of drawings, detailed information and rights to manufacture under its patents. The leading feature of the Creusot method was forging the armour under a great steam-hammer, — a method now practically abandoned.

A striking instance of how rapidly, in these days of progress, costly machinery loses its value and is set aside by the onward march of improvement is thus exemplified by the great Bethlehem steam-hammer. This hammer, with a falling weight of 125 tons (25 per cent. heavier than the Creusot hammer), was constructed at very heavy expense, but was used for only three years, and, being then supplanted by a 14,000 ton hydraulic forging press, has since stood idle. Another case of this kind is presented by the elaborate and costly tempering plants erected by the Bethlehem and Carnegie companies, which were required in the manufacture of homo-



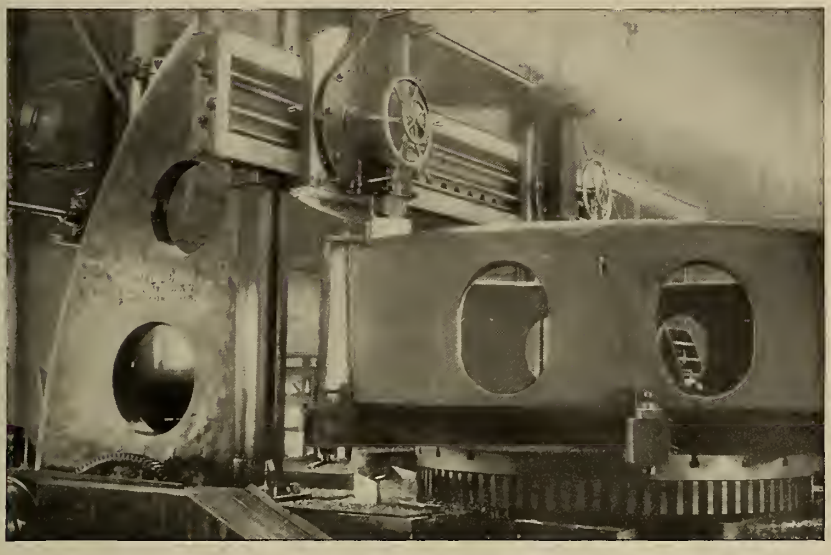
SWINGING A 12-TON INGOT UNDER THE FORGING PRESS AT THE BETHLEHEM WORKS.



TRIMMING AND FINISHING ARMOUR PLATES AT THE WORKS OF THE BETHLEHEM IRON CO.

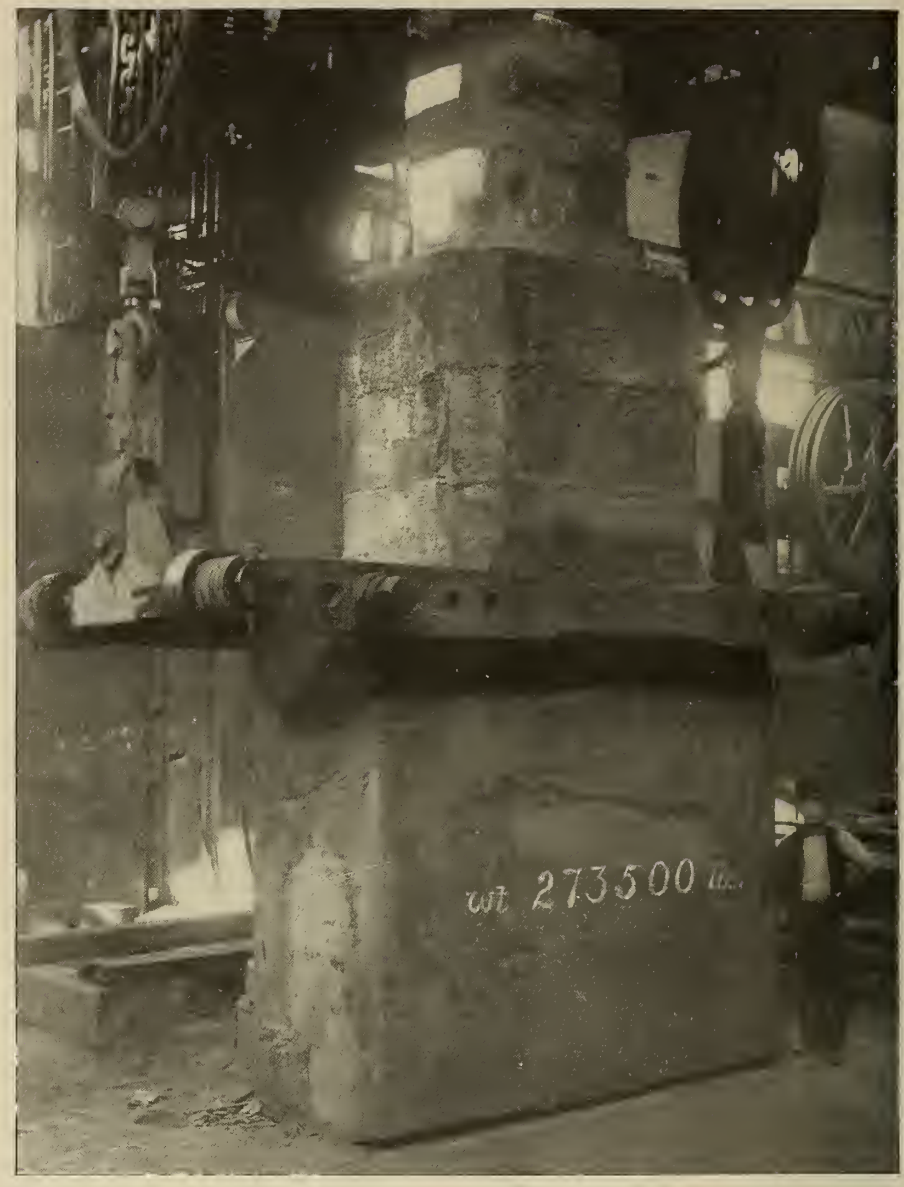
geneous armour by the Creusot method, and which were not necessary for making hard-faced armour. These facts show what large expenditures for special plant and skill are necessary in order to be able, at all times, to produce armour of the highest quality.

As to the cost of making armour plate, a prominent director of the Bethlehem Iron Company recently informed the writer that neither the Bethlehem Iron Company nor the Carnegie Steel Company had ever made a statement as to the actual cost involved. Both companies were urged to do so by the United States government, but have not considered that the latter had a right to ask it, or that it was good business for the companies to comply with the requests. In all discussions of the subject, the armour manufacturers have simply used estimates prepared under orders from the Navy Department by naval inspectors stationed at the armour-plate works, which estimates were based only on information which the inspectors could gather without reference to the manufacturers' books. However, the following brief statement, necessarily incomplete, will serve to give a fairly approximate idea of the cost:—



MACHINING A TURRET FOR 8-INCH GUNS AT THE CARNEGIE COMPANY'S WORKS.

The Bethlehem Iron Company, in November, 1896, using estimates prepared under orders from the United States Navy Department by government naval inspectors, gave $250 as the cost of material and labour involved in making a ton of armour. To this, they asserted, should be added $78 per ton as interest on $4,000,000 invested in their armour plant, $132 for maintenance and depreciation of the latter at the rate of 10 per cent. per year, and $33 as interest on working capital, estimated at $1,500,000. These figures gave a total cost of $494 per ton. Soon afterward the Carnegie Steel Company, of Pittsburg, stated that, outside of labour and material, the cost of a ton of armour, based on the naval inspector's figures, was $225; the interest on plant, valued at $3,000,000, amounting to $81.50; maintenance of plant, $68; and loss by abandonment of plant when the navy shall have been completed, $75.50. It should be noted, moreover, that although a European firm quoted $1,590,000 as the cost of building a plant equal in every respect to those in the United States, prices are lower now than in 1887 when the Bethlehem Company began its plant, or even than in 1890,



NICKEL STEEL INGOT WEIGHING 122 TONS, CAST AT THE BETHLEHEM WORKS FOR 17-INCH PORT PLATE OF THE 12-INCH GUN TURRETS OF THE U. S. BATTLESHIP "IOWA."

when the Carnegie Company began the manufacture of armour.

The United States naval experts estimate that the cost of labour and material in a ton of nickel steel armour is $148, plus 10 per cent. on that sum allowed for loss from spoiled and rejected plates; in a ton of Harvey nickel-steel the cost is $168.53, plus 10 per cent.; and in a ton of double-forged nickel-steel, $187.80, plus 10 per cent.

As a result of these investigations, the Secretary of the United States Navy concluded that the present value of an armour plant, like those of the companies referred to, is $1,500,000, and

the allowance for maintenance $150,000 per year while the plant is in operation, and that $250, in round numbers, may be taken as the cost of armour when the companies have fair orders for work. This is very near the figure of the Bethlehem bid for armour to the Russian government, which was $249. However, this low bid was made, the Bethlehem Company claims, in order to get into the European market with American armour.

Allowing 50 per cent. (for profit and interest on capital invested) upon the above cost of manufacturing armour for United States battleships now under contract, would make $375, which, plus $20 for the nickel in the armour, gives $395 per ton, or, in round numbers, $400. This, the secretary stated, seems to be an equitable price to pay for armour for the vessels in question, and $375 per ton, if Congress should authorise the construction of any additional battleships. The two American companies now demand $425 per ton, and claim that the average market price of the world for armour is over $500

PRESENT-DAY SHIP BUILDING PROBLEMS.

By Professor W. F. Durand.

THE general theory of naval architecture may be divided into the three chief heads, statical, dynamical, and structural. The statical theory involves for the ship, in the upright position and at various drafts, all computations relating to the volumes, displacements, areas of midship section, water plane, wetted surface, the various coefficients of form, the centres of buoyancy, the metacentres, the initial surface stability, moment for change of trim, and others.

Similarly, for the ship in the inclined position, it involves all computations relating to volumes and centres of buoyancy for varying immersions, so that, knowing the location of the centre of gravity, the stability or righting lever can be found; and, hence, by an appropriate combination of the values thus determined, the stability curve for the ship in any given condition may be determined. We may also have various special applications of the general theory to particular problems, such, for example, as the investigation of launching conditions; the influence of added or subtracted weights on trim, heel and stability; the influence of liquid loading or water in bilged compartments, and others.

In all such computations the object in view is geometrical in character. In consequence the theory involved may be said to be complete and perfect. That is, the theory does not transcend the limits of ordinary pure mathematics, and we know exactly the mathematical nature of these computations and how to decrease the practical error to any desired limit. The only limitation arises, therefore, not from any imperfection of theory, but simply from the inability of certain mathematical processes to deal exactly with the data in the form supplied, and from instrumental and personal errors.

The fundamental data of all these computations are found in the external form of the ship as determined by the lines. The actual surface is not mathe-

matical, but topical,—that is, determined empirically and not as the expression of any definite or known mathematical law. The only method of representing such a surface on a plane is, of course, by sections; and according to their nearness, and hence the number of the measurements thus provided, so will be the hold on the character of the surface itself.

The actual data consist then in sections,—vertical or horizontal,—as determined on the drawing board, or in measurements taken from them as laid down on the drawing board or mould-loft floor. If the data are to be used in the numerical form, the various rules for approximate integration are used according to the problem in hand, and, as above noted, the accuracy obtainable is dependent simply on the number or nearness of the measurements which enter into the determination.

If the data are to be used in the form of curves or sections, then the planimeter or integrator may be used to find their areas or moments. These, again, may be plotted in a curve and their integration will be represented by its area. This may be determined by a second application of the instrument, and thus the entire operation may be made instrumental and geometrical rather than numerical.

We need not tarry longer over computations of this class, since, as already noted, the theory is complete, and we know how to find any of these statical or geometrical functions of a ship with any degree of accuracy which may be desired.

Improvements in this direction cannot, therefore, come in the way of general theory. Neither should we look for any great advance in the present methods of computation. A surface such as that of a ship can be represented only by its varying sections, and these only by their form or various ordinates. If the methods are numerical they must of necessity take into account a certain number of ordinates or measurements, and the lowest permissible number for desirable accuracy is now pretty well known. Similarly if an instrument is used, we must do something which takes cognisance of the form of the section. This can hardly be done more simply than by traversing its perimeter, as now. Hence, while various new methods for computation may be devised, the elements of novelty must necessarily deal rather with the minor arrangements of detail, and we can hardly hope for any great advance in the fundamental nature of the computation or methods themselves.

While, therefore, in the direction of fundamental improvement the prospects of substantial advance seem remote, it by no means follows that it may not be possible to make valuable improvements in the way of a better presentation of known data relating to these features. Suppose, for example, that we have determined for a large variety of forms the various geometrical functions, as already mentioned. It is then possible, by means of empirical equations, to formulate various relations between them, and thus to express certain of the more complex, such as the centres of buoyancy, metacentres, and others, in terms of the more simple or fundamental, such as the dimensions and coefficients of form.

With these equations it is then possible, for any proposed ship of not unusual form, to express, with some approach to accuracy, the values of these various functions in terms of its fundamental characteristics. Much has already been accomplished in this field by Normand, in his "Formules Approximatives de Construction Navale." There still remains much, however, which might be done, especially in the closer adaptation of the equations to various types of form. Again, it might be possible by an analysis and combination of the data relative to stability, to determine empirical formulæ for certain classes of vessels which should serve at least approximate or preliminary purposes.

We will now turn to the theories relating to the dynamics of naval architecture. The more important of these are naturally those that relate to resistance, propulsion, and powering. We

meet here with an entirely different set of conditions. The quantities dealt with are physical rather than geometrical, and the theories by which we attempt to express their relation to known characteristics of the ship are admittedly imperfect and empirical. There is, in fact, no complete general theory whatever connecting the various phenomena involved, and for working approximations we are dependent entirely on empirical formulæ as the direct expressions of experience.

From the inherent nature of things, this will probably always be the case, and we need not hope for any complete, absolute and self-contained theory relating to dynamical features such as resistance and propulsion. This is readily seen by a consideration of the question, for example, as to the method of representing in such a theory the influence of varying degrees of roughness of surface. That is, how could rough surfaces be classified mathematically, or what geometrical function of such a surface would answer as a representation of its influence on skin resistance?

Or, again, what geometrical function of the form is capable of exactly representing the energy necessary to the maintenance of the train of waves accompanying the ship? Pure theory is entirely helpless in the face of questions of this character. Of necessity, therefore, a working theory must have its foundation in experience, and must aim simply to be the expression and generalisation of such experimental foundation.

In order that a theory of this character may satisfactorily cover the ground involved, the results of experience must be available for sets of conditions distributed at intervals all over the range to be covered. The expression of such results by formulæ is, then, simply a generalisation of experience to cover all values of the conditions within the limits, and therefore a provision for ready and accurate interpolation between the results determined by experiment.

Suppose, for example, that we had available for the general class of mercantile steamer the resistance at varying speeds for, say, one hundred selected types! It is at once evident, if this information could be thrown into the form of an equation giving the relation between resistance and the chief characteristics of the forms used, that such general equation or statement of relationship might safely be taken for any ship whose characteristics were within the range of those covered by the investigation.

In a similar way the principle might be extended, and it is quite within reason to believe that experiments on five hundred or six hundred carefully selected types of form would give a very satisfactory general relation between resistance and the characteristics on which it depends. Instead of algebraic formulæ it might be preferable, practically, to express the data geometrically; but in either way the ultimate result would be the same. These fundamental principles are the same for all empirical theories, and their development must necessarily proceed along these lines, no matter what the nature of the quantity dealt with.

Now, taking the one question of resistance, let us note the condition of our empirical knowledge relative to this feature! In the first place, we may note that there exist a vast amount of experimental data giving directly the resistances of models about ten or twelve feet in length, such models representing ships of various types and sizes. In order that these experimental data may be applied to ships of full size, certain assumptions are made by which the total resistances of both model and ship are divided into two parts, one known as the skin resistance and expressible as an empirical function of wetted surface and speed; and the remainder known as the residual resistance. Between the residual resistance of the model and ship the relation expressed by the so-called "law of comparison" is then considered to exist.

By the aid of this law the experimental data for models are made available for ships of the same geometrical character, but of varying sizes, there being a particular ratio between the speeds of the

model and ship at which this relation holds. Such speeds are known as "corresponding," and the ratio between such speeds for two geometrically similar forms is the square root of the ratio of the linear dimensions.

The statement of the law is, then, that for similar ships at corresponding speeds, the residual resistances are in the ratio of the cubes of the linear dimensions, or, the resistances are as the volumes. In this way we may relate the resistance of the small model at one speed to that of the ship at a corresponding speed, and thus relate the design of full-sized ships to experimental data without the necessity of continued experiment on the full-sized forms.

The use of model experiments in this way depends solely on the separation of the total resistance into two parts and the determination of one directly by an approximate formula, and the other by the law of comparison, as stated above. Still more directly, the law of comparison is frequently considered to relate to the whole resistance instead of to the residual only, and hence the step from the resistance of the model to that of the ship requires simply the application of this law.

While the law of comparison is sometimes treated as though it were complete or perfect, it must not be forgotten that such is not the case. It may, indeed, be derived as the resultant of certain physical assumptions relative to the properties and condition of the liquid—assumptions which in the actual case are only imperfectly fulfilled. The substantial truth of the law and our confidence in it rest rather, therefore, on the close agreement between the results given by the law, and the results of experiment with full-sized forms, and on the general verification of the law when applied to the comparison of full-sized ships of similar form.

We have thus pointed out in a very brief way the nature of the data which may be made of use in establishing a relation between the resistance of a ship and its characteristics, and it has been stated that a considerable amount of such data is in existence. While such is the case, it is, unfortunately, not available to the general public. Experiments along these lines have been carried on it Great Britain, Holland, France, Italy, and Russia.

These data are mostly in the possession of the departments of naval administration in the various countries, and are used in the study of questions which arise in their current designing practice, each using its own collection. It is a matter of profound regret from the scientific standpoint that this very extensive collection of data cannot be placed in the hands of competent investigators for analysis and combination into an approach to a general law of resistance. While there has probably been much duplication of effort at the various experiment stations, yet it would, doubtless, be found that such a combination and analysis of all existing data would cover very satisfactorily the range of all ships except those of very unusual forms.

In a similar way the action of propellers and paddle wheels may be studied by means of comparatively small models, and the results related to those for full-sized propelling agents by somewhat similar laws of comparison; that is, by means of laws having their foundation in theoretical reasoning, supplemented and controlled by the nature of the agreement between the results thus obtained and the results of actual full scale experiment. On this subject likewise much has been done, though still more remains for the future.

It is in connection with the general subjects of resistance and propulsion that the present condition of scientific knowledge is the least satisfactory. The possible work of the scientist in this direction is very largely conditioned on the possibility of obtaining more data, and until a large additional store of practical information becomes available, we can hope for no satisfactory general working theory relating to this portion of dynamic naval architecture.

In addition to the general investigation of the features above noted, further information is much needed on the subject of engine friction. This is the one

remaining item needed to make complete our hold on the various constituents of the indicated horse-power. With satisfactory working theories for resistance and propulsion and for the power absorbed by friction under what may be considered standard or usual conditions, we should be in a position to determine the indicated horse-power necessary for any given case with reasonable certainty, instead of, as now, being obliged to work with a large margin of probable error, due simply to our comparative ignorance of the quantities involved.

In addition to the dynamical theory relating to resistance and propulsion, there are various other branches of the same general theory. As the most important, mention may be here limited to theories for waves and wave motion, rolling, influence of bilge keels, action of the rudder, and the interaction of rudder and propeller.

In regard to wave motion, a considerable amount of work has been done in the devleopment of mathematical systems of simple wave motion, with a view of comparing their characteristics as deducible from theory with those observed in actual waves. Of these the trochoidal theory, or system, while not altogether satisfactory from the mathematical standpoint, may be considered as quite satisfactory to the naval architect for the purpose to which he wishes to put it. All such theories are necessarily limited to a single train of waves, or, at most, to relatively simple combinations.

No theory whatever can pretend to cope with a more or less confused sea such as usually exists in the actual case. Under such circumstances wave theories are used by the naval architect for the examination of ideal extreme cases for comparative purposes, rather than for obtaining results considered as absolute in themselves. For such purposes, the existing theories, admittedly inexact and tentative, are reasonably satisfactory, and it can hardly be said that the naval architect is in especial need of any great extension or development of theory relating to free or open-sea wave-motion.

It may be well, however, in order to prevent misconception, to point out that much remains yet to be known relative to the constitution and reaction on the ship of the train of waves generated by its motion through the water. These features are considered as pertaining to the subject of resistance, and their examination would naturally appear as a part of that general investigation.

It may also be noted that there are several matters to which waves have a causal relation, relative to which more information is much needed. One of these is the influence of a train of waves or a generally rough sea on resistance and the power required for propulsion. We know in general that it is increased, and rough estimates may be made for average weather. More definite information on these points would, however, be of much value. Similarly, while we have a fairly complete theory of rolling, both in still water and as affected by a regular train of waves, definite actual data relating to the rolling of ships in a sea-way are rare and much to be desired.

On the general subject of rolling, as just noted, we have a fairly satisfactory theory; but, like all others of its kind, it is simply a way of expressing experience, and the amount of experience with which to compare the theory and control the values of the various coefficients, is, unfortunately, very small. We know in a general way on what characteristics of the ship the rolling will depend, and also in what way a variation in most of these characteristics will affect the rolling. What is needed is not so much more theory, as more data with which to make our theories practical and useful.

In common with all theories of this class, the rolling of a ship may be expressed in terms of certain characteristics and certain constants or coefficients. It is by means of these latter that we are enabled to relate theory with experience, and, by a comparison, derive values of the coefficients for various typical cases which shall cause the theoretical expressions to agree with the results of experiment. It is just here that the theories relating to rolling ar-

weak. The equation to the so-called curve of extinction, for example, is expressed simply as a function of the angle of heel and one or two coefficients. These latter depend, of course, on the characteristics of the ship, but just how is not known. Now a large collection of data would doubtless make it possible to trace a general relation between these coefficients and the characteristics on which rolling is known to depend,—displacement, moment of inertia, metacentric height, fine or full form, bilge keels, etc.,—and thus we should have a general empirical equation for rolling, instead of the present unsatisfactory makeshift.

Similarly with the influence of bilge keels, which is, in fact, one of the elements entering into the general question of rolling. Experience with bilge keels on the British battle ships of the *Royal Sovereign* class has shown that the particular coefficients by means of which it was sought to relate their size and velocity to their influence on the roll, were widely at fault; and that the influence was actually many times that which would have been supposed from the existing data. This whole field needs thorough investigation, and until an adequate supply of data is available, no satisfactory working theory can be formed.

Passing to the rudder, we find a similar state of affairs. We have a general theory of the action of a blade, like a rudder, oblique to a current. The theory is empirical and imperfect, and various modifications are known to be necessary for its application to the case of the actual rudder. Still, with all its imperfection, it could, doubtless, be made to do satisfactory duty as a working theory, if only we had the data wherewith to determine the necessary coefficients. There is indeed a large amount of general information available, since every ship has a rudder and a general judgment is readily obtainable as to its sufficiency or otherwise. As to the actual forces involved, however, and the nature of their dependence on the various features of the case, we are sadly in need of more definite experimental information.

With the interaction of the rudder and propeller, we are still more dependent on experimental data. This is a subject difficult to treat from the theoretical standpoint because the influences of the rudder and propeller on the direction of the ship's motion are, or may be, antagonistic, and the final result will depend on a balance or difference of such elements. Just how the balance will turn depends on the special circumstances, and hence such questions can be satisfactorily treated only by comparisons with a large store of accumulated data.

We will now turn briefly to a consideration of the condition of the theories relative to strength, and the qualities of the material entering into the ship's structure. The longitudinal stress on the structural members of a ship is considered as arising fundamentally from the difference in longitudinal distribution of buoyancy and weight. This, in perfectly still water, will give rise to a series of virtual loads, producing a consequent condition of distributed stress. In the actual case the condition thus readily imagined is very much modified by various circumstances, of which we may note more particularly the following:—

(1) Wave motion. This changes the distribution of buoyancy, both by the variations of pressure in the water and by the change in the amount of the ship actually immersed.

(2) Rolling, pitching and dipping. These change the distribution of buoyancy by varying the immersed portion of the ship, and the virtual weight by modifying through accelerations and retardations the forces acting on the mass of the ship and cargo, so that they are no longer represented by their weight, as when the vessel is at rest.

(3) Torsional stresses, due to a difference in the tendencies acting on different parts of the vessel.

(4) Transverse stresses, arising in the same general manner as the longitudinal stress above mentioned.

(5) Racking transverse stresses, due to accelerations and retardations in the velocity of roll.

(6) Local stresses, more or less severe, such as those due to the propellers, to the rudder, to the discharge of heavy guns, or localisation of heavy weights, etc.

The combination of these various stresses results in a condition of compound stress, continually changing, and so complex in its make-up and relation to its constituents as to be entirely beyond the reach of mathematical analysis, even empirical. The controlling conditions are extremely variable and complex, and cannot be made sufficiently definite to enter into a mathematical statement of relationship between themselves and the stresses to which they give rise.

It must, therefore, be realised at the very outset that the stresses which the naval architect computes are not supposed to be actual. Instead of that, he computes the stresses which would exist under a set of ideal conditions, and these he compares with the stresses computed under similar conditions for ships of like general structure, the scantlings of which have shown themselves, by experience, to be adequate to all usual conditions. This comparison may then serve as the basis of a judgment as to the relative sufficiency of the material in the proposed case.

Once having adopted this method, the details of procedure are entirely simple, so far as general theory is concerned. The accepted theory of the beam is taken. We have, then, simply to compute the external and internal moments. The former are functions of the longitudinal distribution of buoyancy and weight. For the first a wave contour is usually taken of length equal to the ship, and height equal to one-twelfth to one-fifteenth or one-twentieth its length.

Neglecting the variation of the distribution of pressure from that for a like mass of still water, the determination of the distribution of buoyancy is then simply a matter of geometry, and the methods and principles of the statical theory become immediately applicable. The distribution of weight throughout the length of the ship involves simply determinations from the drawings, and from the schedules of known weights of structural material.

The internal moment is proportional to the moment of inertia of the cross sectional area of available material. The determination of this is simply a geometrical exercise.

As a simpler mode of determining the external moment, it is not uncommon to take it as a certain fraction of the product, displacement times length, such, for example, as $D\ L \div 35$, or $D\ L \div 40$. This, of course, is wholly arbitrary, but justifiable for comparative purposes.

On the general subject the naval architect is not so much in need of more or better theories for the computation of the actual stresses,—he does not expect to be able to do that,—as he is in need of more accurate information relative to the actual amount of stress to which given ships are subjected under varied conditions such as exist in actual practice. A general knowledge of the amount of stress and strain produced in the various structural members during a voyage, taken in connection with the circumstances of the case would afford the data most needed; and the gradual accumulation of such information would soon place in the hands of the designer the means of forming a reliable estimate of the maximum stresses to which his ship would be likely to be subjected.

It would, furthermore, serve to show which members were unduly heavy, and which were more likely to be severely strained; and would thus make possible a more efficient distribution of material than is possible under present conditions.

Merchant ships at the present time are usually designed to fulfil the conditions specified by some one of the various registration societies. These various systems are admittedly imperfect and without scientific relation to an empirical foundation; and there is good reason for believing that under a system with such scientific foundation, the structural material might in many ways be disposed to better advantage than it is now.

Outside of the general problem of the strength of the hull, considered as a girder, we have various special problems relating to local strength still wanting satisfactory treatment. Foremost among these is the strength of a bulkhead. The general treatment of this from the mathematical standpoint has been developed by various writers, but from this standpoint alone the treatment is necessarily incomplete. It must depend on experience to become practical and useful. The amount of experience at present available is entirely insufficient. The same general statements are quite as applicable to many other features of the structural design.

From this brief survey of the field of science as related to the art of shipbuilding, it appears that the statical theory has been well worked up and is in a satisfactory condition. This is possible from its nature. The most useful lines of advance here lie in the direction of providing approximate and empirical relations between the various quantities involved, and in thus furnishing rapid methods for preliminary or tentative investigations.

In the field of dynamical theory pure mathematical development is possible only to a limited extent, and theory must then be based on experience. The experimenter and the theoretical investigator must, therefore, work together, the one to provide the material, and the other to analyse, elaborate and combine. It is in this field that the next great advances in scientific naval architecture are to be made.

RAISING WRECKS IN THE THAMES.

By David W. Noakes.

PROBABLY nowhere in the whole world is the environment so propitious for the evolution of the high-class modern wrecker as that found in the comparatively small river Thames in England.

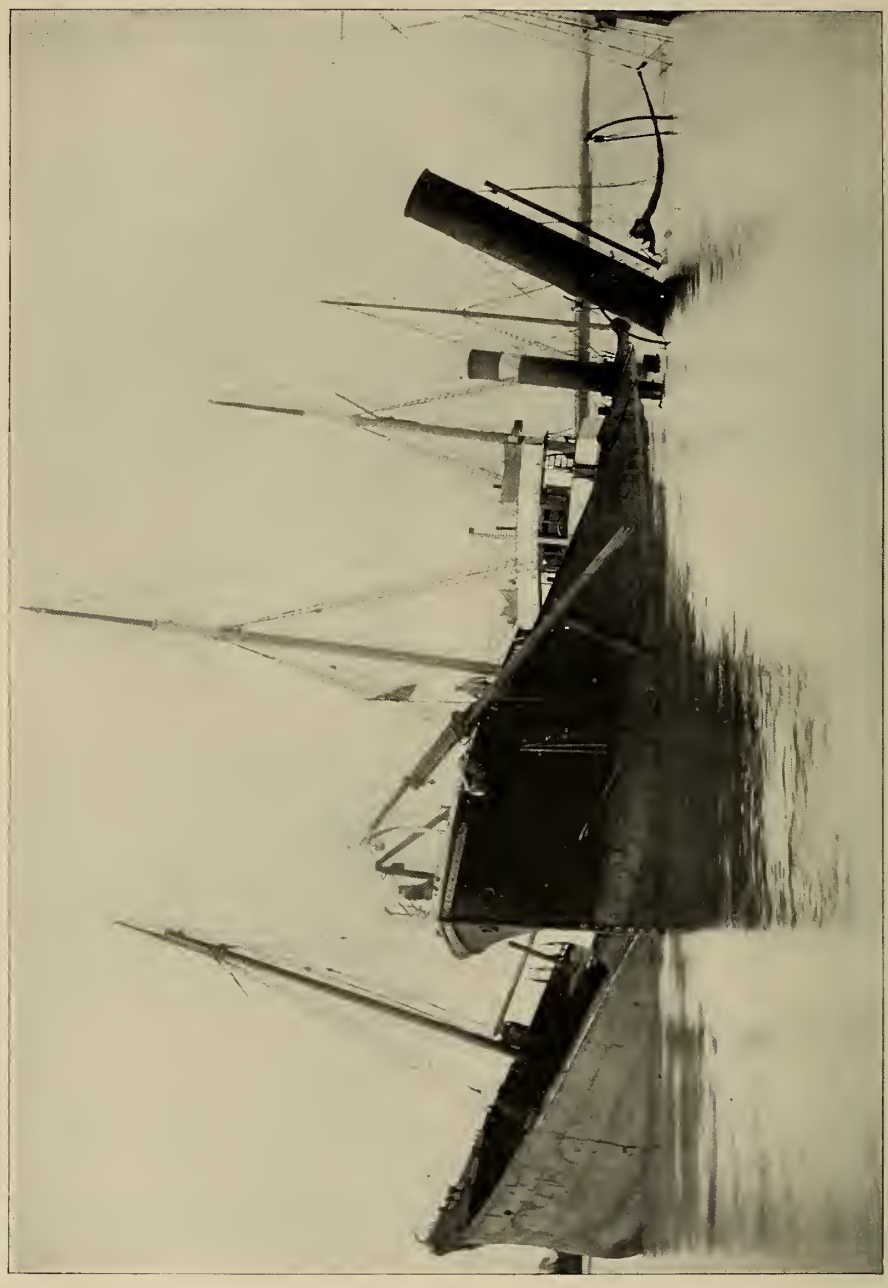
There we have a river dealing with an enormous tonnage whose lower reaches have narrow channels for large and deeply loaded vessels and whose upper reaches are ever crowded with thousands of barges and sailing craft of every description,—a waterway whose banks during the winter months are often enveloped in dense fogs, and whose currents and tortuous windings sorely tax the skill of the most accomplished pilots.

Few people have a correct idea of the immensity of the Thames river traffic whilst it passes uninterruptedly, but let a sudden uprising of fog come on, especially in the upper reaches, and soon the rattle of chains through the hawse pipes, the discord of steam whistles and sounding of numerous bells proclaim, in noisy form, the collection of many vessels; then let the fog suddenly lift, and the reach, apparently clear before the fog, is seen crowded with a hundred vessels to the mile, with masts and funnels in apparently inextricable confusion.

With such abnormal traffic, it should be a matter of little wonder if, at times, the Thames conservators have their hands full, with many onerous duties to perform in trying to keep this congested waterway free from obstructions to navigation. From December, 1896, to April, 1897, twelve steamships had to be lifted from the bottom of the river, nearly all of them sunk by collision. To these must also be added three sailing vessels, including a barque of 700 tons; fourteen sailing barges, varying from 36 to 57 tons each, and numerous other small fry, such as lighters and pier pontoons.

The operations necessary for raising such vessels are ever interesting. In the illustration on page 57 is shown a rather remarkable combination of three wrecked ships which admirably portray some of the difficulties of the work. On the left is the steamship *Newburn*, of 680 tons, with her bows showing well out of the water, whilst just about halfway of her length we have the *Erasmus Wilson*, of 751 tons, sitting on her, with masts and gear as truly vertical in one direction as when afloat on an even keel; in the forepart and at the right is the *Winston*, of 1190 tons, lying on her side, with masts submerged in the direction of the other two wrecks. The photograph from which this view was reproduced was secured soon after the accident and on an extremely low ebb tide, so that it shows the best view ever obtained, and which lasted only for a few minutes.

Taking further advantage of the extraordinary low ebb the camera was quickly moved to the unsubmerged portion of the *Winston* and the view on page 56 was obtained of the *Erasmus Wilson* and the *Newburn*, giving their relative positions and angles of submersion in better detail. The illustrations clearly show that the *Erasmus Wilson* struck and went over immediately forward of the *Newburn's* mainmast, and that the



A TRIPLE WRECK.

Newburn must be almost cut in two, with the heaviest end, containing her propelling machinery, lying in deepest water. The *Erasmus Wilson* also shows her bows to be well out of the water and projecting about 20 feet over the *Newburn*, whilst her after part, like the *Newburn's*, is totally submerged. After a tide or two the scouring action which always takes place, especially when vessels are sunk athwart the direction of the tide, caused the after ends both of the *Newburn* and *Erasmus* manageable, decided to beach the vessels, but in the excitement of the moment, possibly forgetting their increased draft, chose for the purpose an inclined mud shore, more slippery than the greased stocks from which their ships were originally launched. Consequently, as the tide receded, the *Newburn* slid down the mud bank gracefully and erect into deep water, whilst the *Winston*, heavier and more ungainly, endeavouring to imitate her sister in misfortune, clumsily toppled over on her

A VIEW AT LOW TIDE, TAKEN SOON AFTER THE ACCIDENT, SHOWING ONE OF THE VESSELS ON HER BEAM ENDS.

Wilson to settle down, and the view reproduced on page 60 was taken.

The history of this three-wreck catastrophe can be told in a few words,—the *Newburn* and *Winston* collided, the *Newburn* suffering considerable damage, whilst the *Winston's* injury was but slight. Disorder, however, seemed to reign, and an oil ship, inward bound, crashed into the *Winston's* bow, and the latter ship, in her turn, suffered seriously, and soon it was seen that both the *Winston* and the *Newburn* were rapidly settling down. The two captains, unable to tell how many minutes longer their ships would float or be beam ends and became totally submerged.

Ill news travels apace, and quickly; although the wrecks were out of the usual course, the watch boats of the Thames conservators came along with lights to mark the position of the wrecks. The tide again turned, and, flowing over the sunken vessels, the water speedily gained in depth. The night was thick, and the *Erasmus Wilson*, off the usual course, crashed on the submerged *Newburn*. The latter's stringer plate and strengthening pieces ripped out the *Wilson's* bottom, and ship No. 3 became a wreck,—an excel-

PARBUCKLING THE "WINSTON."

lent object lesson of the need for prompt removal of all such hindrances to navigation.

In these days of iron and steel hulls, damage by collision sufficient to cause sinking is inevitably associated with a hole in the hull below water line, through which the water gains access to the interior, and in the absence of suitable partitions forming watertight compartments, all "reserve buoyancy" is soon lost and the ship sinks. If the blow has been sufficient to pierce the ship's skin, it is seldom that the inflow of water through the perforation is within the capacity of the ship's pumps. A hole of 2 square feet area, about 12 feet under water, will let in something like 95 tons of water per minute, and this would require at least three centrifugal pumps, to be started at the moment of collision, with fans 30 inches in diameter, discharging 7500 gallons per minute to keep the water down.

A moment's glance at the gallery of photographs displayed in any ship repairer's office will show that the perforation area is more often 20 than 2 square feet, proving that the ship's pumps in cases of serious accident are comparatively useless. A second glance, however, will also reveal the fact that ships with very bad fractures, bows stove in, and plates buckled, bent and twisted out of all shape, have safely been brought into port and docked, saved from foundering through the friendly intervention of a sound bulkhead which intercepted the free access of water to the whole of the ship's interior, and localised the effect of the injury to such a small portion of the vessel that the reserve of buoyancy was not fully absorbed.

Safety in collision, therefore, depends to a large extent upon the number and efficiency of watertight divisions. Inventors have also, of late years, exercised their talent in the matter of leak stoppers, and vessels of the British Navy are supplied with collision mats. These devices are all based on the very old remedy adopted by Captain Cook, who stuffed a sail into the hole, endeavouring thereby to reduce the inflow of water to less than the capacity of the pumps.

On one occasion it was related before the Institution of Civil Engineers that sides of bacon had been used for this purpose. Such devices, however, are but part of the equipment of a ship and are not embodied in the ship's construction.

Seldom, either outside the navy or larger ocean steamers are such leak stoppers to be found, and if they were it is doubtful whether, in the excitement of a collision, opportunity would be found for useful adaptation. It is very easy when the ship is in dock, or high and dry after accident, to point out what might perhaps have saved it from sinking. The shape, size and position of the injury is then seen, whilst at the moment of collision such data are unknown. Captains in charge, therefore, must feel considerable relief at such critical moments, if they know that their ship is divided by sufficiently small watertight compartments, so that several can be pierced without altering the trim or list of the ship to the point of instability.

In many passenger steamers, especially of the pleasure class, for better accommodation, such bulkheads have sliding doors, with means of opening and closing them from above deck, and in order that the crew should be well rehearsed in their duties should emergency occur, orders are occasionally issued at unexpected times, to close such doors, sometimes exciting considerable mirth. On one occasion, travelling down the Thames on the *London Belle*, on which such doors exist, dividing the dining saloons, a number of hungry passengers who were only partially served found the door quietly closed, and for a short time their joint was cooling on one side of the bulkhead and their vegetables on the other, causing banter and chaff from those more fully supplied. The closure, however, lasting only a few moments, humour was soon restored by a passenger remarking "that he infinitely preferred a cold dinner to a cold bath."

Oftentimes bulkheads are found watertight from the bottom upwards, but not tight at the juncture to the deck. Under such circumstances their usefulness is materially reduced. A moment's consideration will show that if one or more compartments are bilged, either reducing the reserve of buoyancy, or altering the trim or list of the ship sufficient to bring the top of a bulkhead below the outside water line, the inflowing water will have access to other divisions over the top of the bulkheads and the ship will fill and sink.

Let us now return to the operations necessary for raising the three sunken vessels already mentioned. There is practically no choice in the matter as to which must be first lifted, as the *Winston's* position is slightly farther up the river than that of the *Erasmus Wilson* and of the *Newburn*, and if any attempt were made to lift the *Erasmus Wilson* or *Newburn* first, the flowing tide would drive the whole bunch of craft used for lifting on to the submerged *Winston*. Therefore, operations must of necessity commence with the *Winston*, and the first operation attempted is to stand the ship upon her keel, as in her present position she is on her beam ends, with mast and rigging lying on the bottom of the river.

DIVER GOING DOWN TO FIND OBSTRUCTION TO SWEEPING CHAIN.

Two sets of men in two rowboats each take one end of a chain whilst the middle part is thrown overboard and allowed to drag on the river bottom. Then the men row in such directions as to drag the chain under the bow of the

vessel. This operation is technically known as "sweeping." After several attempts, the men are generally successful.

The Thames Conservancy possess five lighters, which are constantly used in their mooring and wreck-raising service. These vessels are 70 feet long by 24 feet beam. Two of them are fitted with powerful hand winches and the three others are equipped with still more powerful steam winches operated by 12 H. P. engines. These three lighters have also strong davits, 3 feet 6 inches wide, projecting over their bows, fitted with three sheaves, and below decks are centrifugal pumps with 10-inch discharges, also operated by the winch engines. These lighters are capable of carrying, when pinned to sunken vessels, about 150 tons each, and upon them falls the brunt of the preliminary operations of placing in position and regulating the steel carrying cables, whilst to four other larger and specially designed lighters, capable of lifting in the aggregate 1400 tons, is delegated the task of carrying the wreck when slung.

Having successfully passed the small sweeping chain under the *Winston's* bow, two of the steam-fitted lighters are called into requisition and a larger chain is attached to one end of the sweeping chain, and, being paid out from one lighter, is hauled under the sunken vessel into the other lighter. As soon as the end of the chain reaches this second lighter, a still larger chain is attached and hauled back again by the first lighter; this sea-sawing operation is repeated several times, and each time a larger chain is used until one of sufficient strength is reached, capable of hauling a steel wire rope, with its large and cumbersome eyes, under the vessel,—an operation more or less difficult according to the hardness of the bottom or the direction the vessel bears relative to the set of the tide.

THE "ERASMUS WILSON" ON TOP OF THE "NEWBURN."

During the sea-sawing operations, whilst passing the preliminary chains, the lighters are also hauled backward or forward, in the direction of the sunken vessel's length, so that the wire can be finally placed under the portion of the ship desired. In this matter considerable judgment and experience is necessary, both as to the number of wires necessary, and their position, depending upon such factors as the structure of the ship, the position of engine room, nature and distribution of the cargo, point and extent of injury, and others.

The first wire having been sucecss-

fully placed, another set of similar operations is commenced in order to pass a second wire under the wreck; but, many attempts failing, the diver dons his suit and descends to find the cause of the obstruction. It is then discovered that as the ship is on her beam ends, the operation of passing the first wire has dislodged from the almost vertical fore deck a spare anchor and davits and other gear, which, falling over the ves sel's bulwarks, only a foot or two above the river bed, effectually prevent the passing of the second sweeping chain. The diver has to cut away the fore-stay, unshackle the anchor from its cable, and sling the loose obstructing pieces, which are then hauled to the surface. The next attempt to pass the sweeping chain is more successful, and one of those constantly occurring and worrying incidents to the wrecker, when a comparatively small obstruction occasions much loss of the very valuable working time between the tides, is successfully overcome.

Having passed six wires under the hull, preparations are made for standing the ship erect, the process adopted on this occasion being that of parbuckling. The *Winston* had received her injury on the starboard side in the fore hold, the gash being unusually extensive, and after sliding down the steep mud bank, had keeled right over with her starboard side to the river bottom. The six wires to be used, therefore, pass from the lighters vertically downwards and completely under the starboard side of the ship which is in contact with the river bottom. Then they pass upwards, by the keel, are led over the port side and attached to the ship's masts, or other strong existing or improvised fixings.

At dead low water all slack on the wires is taken in, and the six ends are securely fastened to the lighters, and the *Winston* now lies in a sort of cradle formed by the six wires passing under her. As we must now wait for the flowing tide, all hands, except several men to watch, are piped below for dinner, and we have time to consider what may be expected to occur.

If the fixings to which the wire ropes are attached are equal to the strain; if the wire ropes do not break; if the buoyancy of the lighters is sufficient; and if the rise of tide, *minus* the depth lost by lighters whilst pinning, is equal to the ship's beam, then the sunken ship's starboard side will be gradually lifted, until she is erect upon her keel. On reference to the illustration on page 58, it will be seen that a group of three lighters to the left and three to the right of the wreck are just beginning to pin down, and as the first part of the lift is the heaviest, the centre vessel, fitted with a set of shears, is lending assistance by heaving on one of the submerged vessel's masts by means of a wire attached at considerable distance from the deck in order to gain leverage.

A VIEW AT HIGH WATER, SHOWING THE LIGHTERS CARRYING OF THE WRECKS.

The centre vessel, fitted with the shears and known as the screwing lighter (in consequence of the hull being in twin separate parts with a well between and fitted with gantry and screwing tackle for putting down screw moorings), is provided with a steam windlass

capable of exerting over the shears a strain equal to some 15 to 20 tons. This strain, assisted by the leverage accorded by attaching to the *Winston's* mast at about 30 feet from the deck, snaps the mast in two; but such a contingency having been anticipated, the screwing lighters are promptly removed to the other mast, which proves equal to the necessary strain.

Turning a ship up from her beam ends to an erect position requires far less lifting power than when bodily lifting the sunken vessel to carry her into shallower water, and can be attempted, as in this case, even when the tides are not at their best. Unfortunately, the tide is a sluggish one, flowing with but little energy, and the factor of assistance (at times very considerable) rendered by a fast tidal current flowing in the direction of the lift is almost *nil.* The sluggish flow of tide means also loss of lift, the rise being below the normal, and for a few minutes we are almost despairing of success, especially as the weight upon the lifting lighters is the maximum estimated as necessary to erect the sunken ship.

Finding no more assistance likely to be gained from the tide, new orders are issued and the comparatively quiet scene of a moment ago is filled with the noise of winches, rattling of chains, grinding and straining of ropes and wires, and the hurry and bustle of men, for the next ten minutes mean either success or failure.

The position is this:—The lighters with hand winches and the two steam-winch lighters have each one lifting wire attached to their respective winding gears, this lifting wire being led either over the bow or stern. Leading the lifting wire over one end of the lighters materially depreciates their lifting powers, but we have to bear in mind that all the lifting craft must be clear of the sunken vessel's masts and funnel when she lifts.

In a few moments the two steam winches have brought their respective lighters' bows so far down that the tide is flowing over their fore decks, their keels out of the water, and their maximum lifting power fully exhausted; then one by one, to the capstan song of the men, and the clank, clank, clank of the pawls, the powerful hand winches put more and more strain on their wires till suddenly the pawls quicken their pace; there is a shout from the men, a sudden commotion in the water, as great rushes of air and the masts and funnel emerge, and a victorious shout proclaims that the *Winston* is once again upon her keel.

The rush of air seen when the wreck is suddenly lifted and the continued later bubbling-up of air point to the fact that the ship's ballast tanks and portions of the holds contained a large quantity of it. The quantity and position of the imprisoned air neutralised to a considerable degree the lifting power of the lighters, and doubtless was the factor causing the maximum of lifting power necessary.

The first operation being successfully completed, preparations are at once made for slinging and carrying the wreck into shallower water. According to *Lloyd's Register*, the *Winston* is an iron ship 246 feet long; beam, 32 feet; depth of hold, 18 feet; gross tonnage, 1419; loaded with a general cargo, including a large quantity of grain.

Six more steel wires are passed under the ship, making, with the six used for the parbuckling operation, twelve in all. Each of these so-called wires is made up of straps, varying in length and held together with heavy shackles. Each strap consists of two 7-inch best quality flexible steel wire cables, made especially for the work by Messrs. Bullivant & Co., Ltd., of London. The straps are made up and kept in lengths of from two to twenty fathoms, each length having a large steel eye at each end. It is obvious that such an arrangement is necessary in order that certain lengths may be selected and shackled together to form, in the aggregate, the necessary length required.

As the wreck is totally submerged at low water, it follows that the first lift will be the lightest, the weight to be lifted depending on the relative specific gravity of the ship and her varied cargo.

In the case under consideration the weight to lift is estimated not to exceed 1000 tons. The weight will remain constant during the whole time the wreck is submerged, but will increase later as more and more of the vessel shows above water level.

The correctness or otherwise of the estimation of weight to be carried will be conclusively proved by observing the extent of submersion of the carrying lighters. On this occasion four lighters are used, two capable of sustaining, when submerged to load line, 300 tons each, and two 400 tons each. The load line allows a good margin of free board, and as the lighters have perfectly watertight hatchways, they could be completely submerged without sinking, and, combined, would carry several hundred tons more. But even with such wide margins of safety it will be seen that a good deal of experience and judgment is necessary as to the number, distribution, and regulation of the wires, so that to each of the lifting lighters is apportioned a burden suitable to its capacity, and the wreck itself is cradled in the wires in such a manner as not to add further to its injuries.

These points being duly observed, the two pairs of lifting lighters are brought alongside, one 300-ton and one 400-ton on the port, and one 300-ton and one 400-ton on the starboard side. All the lighters are placed with their heads in the same direction as the wreck. The steel wires are now taken on board. During the parbuckling operation six single wires only were used, but now the wires are used in pairs, each pair consisting of a near and off wire, arranged as follows:—From the starboard side of the 300-ton lighter alongside the port side of the wreck descends a wire which passes completely under the wreck and rises to the port side of the 300-ton lighter which is on the starboard side of the wreck.

At each end of this carrying wire, which is known as the "near wire," is a large eye. The "off" wire passes under the wreck immediately alongside the near wire; but it leaves the port-side lighter on the latter's port side, passes under the lighter, then under the wreck, then under the starboard lighter and rises from the water on the starboard side of that lighter. This "off" side wire has also a large eye at each end, and the lengths of wire chosen are such as to just bring the eyes of the near and off wires on to the respective lighters' decks. Through each pair of eyes is rove, five or six times, a smaller wire about 3½ inches in circumference. In this manner ten other wires are taken on board, consisting, as before, of five "near" and five "off" wires. Three pairs are attached to the 300-ton lighters and three pairs to the 400-ton lighters, and all are made ready as far as possible for hauling tight.

As soon as it is judged to be dead low water, the smaller wire rope, rove through the eyes of the larger carrying wires, is hauled in by the steam winches simultaneously at each pair of ends until the eyes are close together, or they are judged to be in a position relative to the other wires to receive their proper strain. The other five pairs of wires are treated in the same manner. The 400-ton lighters are fitted with Bullivant's automatic nippers, and the carrying wires are passed through these in such a manner that, if need arose, the wires could be quickly slacked away. The tide is now swelling, the lighters are all pinning, and it will be seen that if the lighters are equal to the wreck's submerged weight, and if the wires do not break, which they rarely do, the sunken ship must be bodily lifted in the wire cradle in which she is slung.

Slowly but surely the lighters pin down to their work. Every now and then a wire may break through some weak obstruction, such as the bulwark, and will cause an ominous report, alarming the inexperienced wrecker perhaps, but making no impression on the genuine, old, case-hardened man of steel wire rope.

One of the most interesting things is waiting for the cry, "We drive." Often we have watched, with marks upon the shore, to get the first indication that the bunch of craft is moving. The lighters have now evidently got

down to their work; they keep the same trim and list, but do not deepen. Then comes the looked-for cry, "We are driving." The tugs are put on, and slowly the carrying lighters, the submerged wreck, the steam lighters and rowboats, in one huge bunch, are towed into shallower water with a flatter and less treacherous bottom.

An ordinary spring tide gives 20 feet rise, but 7 or 8 feet loss must be allowed for pinning of lighters, loss on wire and fixings when taking the heavy strain, and loss of time at low water. Anchors are now got out and the lifting lighters are moored out of any danger of sitting on the wreck as the tide falls. Of course, it becomes necessary for the next lift to regulate anew all the carrying wires and take out from each the two fathoms gained.

The experience of this first lift will also prove useful, as from the trim and list of the lighters when pinned, we shall have had clearly indicated if any particular wire or wires have been subjected to an excessive share of the total weight, and adjustments can be made to bring about a more even distribution of the greater weight to be carried during the next lift, when part of the wreck's hull will be above the water line.

The new position of the wreck, upon a more even keel than hitherto, also admits of other preparations being pushed forward and the current of the ebbing tide having eased, it is possible for the diver to descend, and, by means of sunken staffs, to obtain roughly the dimensions of the gash in the starboard bow which caused the vessel to sink.

Having obtained the width, depth, and curve of the ship, fore and aft of the collision injury, the shipwrights set to work to make a covering shield. By this time it is again dead low water, and the busy scene of hauling to and adjusting the carrying wires is once more repeated, and with the powerful swelling incoming tide, lifting the whole bunch of craft, another short trip shoreward is made, and a few hours later on, when the tide has ebbed, we are walking on the *Winston's* decks.

Although the decks ebb dry, the holds are flooded, and a steam "grab," descending at quick intervals with greedy claws, clutches grain or jute or any cargo that it may find below the surface; then, rising quickly, it disgorges its contents into barges placed ready to receive, and in this way the *Winston's* 1800 tons of cargo are rapidly reduced. Then the screwing lighters with their shears lift up the huge wooden shield, to which a quantity of iron has been attached to sink it, and the diver, descending, fixes it in place.

CARRYING LIGHTERS LIFTING A VESSEL.

This fixing of the shield is always a matter of anxiety to those having it in charge, for no matter how clever and experienced the diver may be, he has to work under infinite difficulties. A fathom below the surface he is in darkness; the scouring of the tidal current works deep and treacherous holes in the river bottom alongside the ship, and dealing with a shield 400 feet in area simply by the sense of touch is no easy task. Then, again, large as the shield is, who knows that it covers all the perforations in the hull? The wreck has

been twice in collision. Might not, therefore, other holes exist? Even the veteran chief, with the experience of raising upwards of 500 vessels, cannot with certainty announce success.

A port hole may be open or an anchor prick may exist; perhaps, too, the bulkheads are not tight. Nothing daunted, however, the men work cheerily. The huge suctions of the pumps are fixed as low as possible in the wreck; the tide ebbing just below the top of the after coamings, proves favourable, and soon the "donkey" is busy priming the centrifugal pumps. Five minutes later twenty tons of water per minute are pouring over the side, and the next ten minutes will presage success or failure.

Therefore keen interest is felt as the water, at first slowly, and then more rapidly, recedes, every successive inch indicating a growing degree of success; soon, however, enthusiasm is checked, for the pumps choke with the grain, and once more the water gains. But other suctions are now ready. These lead into the engine room, and the latter, being amidships, will, if its bulkheads are tight, represent valuable buoyancy. Fortunately the engine room proves tight and is quickly pumped out; the fire hold and after hold suctions, freed from their grain, are also again put to work, and as the water level inside lowers, the head of water outside increases and the shield is pressed closer and closer to the ship, reducing correspondingly the volume of leakage inflow, till at last the lightening of the ship demonstrates the fact that the inflow is within the capacity of the pumps and that the wreck is slowly but surely obtaining a reserve of buoyancy.

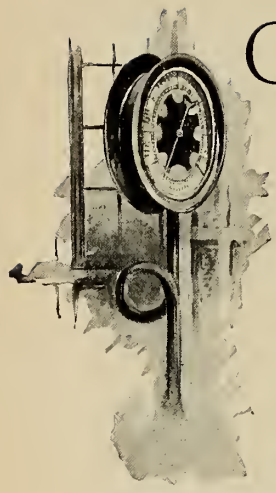
Another short trip shorewards and again the tide recedes, leaving the wreck above low-water mark. More cargo is taken out, allowing the pump suctions to go deeper; the shield, being visible, is caulked tight, and the *Winston* is towed up-river, put into the dry dock, repaired, and, like a good many other vessels that have survived the same ordeal, is again busy, earning owners' dividends.

By a similar series of operations the *Erasmus Wilson* is carefully lifted off the more unfortunate *Newburn*, deposited in the dry dock, repaired, renovated, and otherwise again made ready for service. But alas for the poor *Newburn!* Maimed, battered and sunk by the *Winston*, then, whilst down, sat on and crushed by the *Erasmus Wilson*, she has succumbed to her hard fate. Broken in two, each end was separately lifted and carried in-shore, where to injury was added insult, for her disjointed parts realised only £15.

Still in this unique triple wreck we have not only an example of the high development of the modern wrecker, but also a glimpse at a very interesting department of Thames Conservancy work, which although primarily intended to keep the navigation of the Thames free from obstructions, has also the attendant advantage of preserving annually a large sum of money from Davy Jones's locker.

COMPRESSED AIR IN MINING.

By Edward A. Rix, M. A. Soc. M. E.



COMPRESSED air is the only power which is alone sufficient to supply all the power needs of an average mine. For lighting purposes from five to ten per cent. may, if required, be converted into electricity for that purpose. Where steam or water power is used, fifty per cent., or more, is converted into compressed air, and five to ten per cent. into electricity for lighting. Where electricity is used, from fifty per cent. to ninety per cent. is converted into compressed air, the remainder being directly used for lighting.

The reason for so great a conversion of other powers into compressed air lies in the fact that generally one-half the entire power is absorbed by pumps, underground hoists and rock drills. The two former, in nineteen cases out of twenty, are actuated by compressd air, and the latter always. It is true that both the hoists and pumps may be run by electricity economically, but as yet there has not been produced a rock drill actuated by electricity which has been a success, and inasmuch as air is required for rock drills, and as they consume more than the pumps and hoist as a rule, the mine management generally concludes to use air for all three kinds of work rather than introduce two kinds of power service underground.

I am perfectly aware that my statement regarding the failure of electric rock drills may be disputed by manufacturers of the so-called article, or by electrical enthusiasts, but notwithstanding all that, I shall maintain my statement true, and it will receive the support of the larger electrical concerns.

It is true that electric drills have been made by two or three firms, and on the shop floor they drill very nicely, at the rate of two inches per minute, in medium granite, for the first two feet. From that point on to four and a half feet, the average depth of a blasting hole, their drilling capacity deteriorates very rapidly. The air drill does from three to four times this work easily.

The claim for the electric drill is that it consumes but one-third the power. This is true, but if it takes three of them to do the work of one air drill, the wages of six men will have to be balanced against the wages of two men and the extra power consumption. The latter equals, perhaps, the pay of one man, so that to do the same work with the electric drill would cost twice more than for the air drill.

There are other considerations, however, independent of this, which militate against the electric drill, namely, that it will not stand the dust, mud, water, hammer beating and general rough usage, and again, it would be necessary to introduce a ventilating system for fresh air, as well as to expel smoke, where electric drills are used, while with the air machines their exhaust furnishes all necessary fresh air.

It needs no great discernment to see, therefore, that the simplest and most desirable proposition, and the one involving the least machinery and transformation of one power into the other, is compressed air, which exchanges from five to ten per cent. of itself for lighting purposes only, while any of the others must make exchange for at least fifty per cent. of air and the lighting besides.

I have assumed, of course, that the

RAND ROCK DRILLS OPERATED WITH COMPRESSED AIR AT JEROME PARK, N. Y.

cost of any of these powers delivered to the mine was equal and the motors which absorbed them were the most efficient for the purpose.

All things being equal, then, I assume from what I have seen of the various requirements of a mine for power purposes, and for the reasons given before, that compressed air is the ideal power for general mining purposes. With varying conditions, however, it is simply a matter of combining and comparing the cost of fuel or water, repairs, interest on the plant, insurance and taxes, in order to select the proper general power, and should comparisons be nearly equal, then general utility, simplicity and safety, should decide the choice.

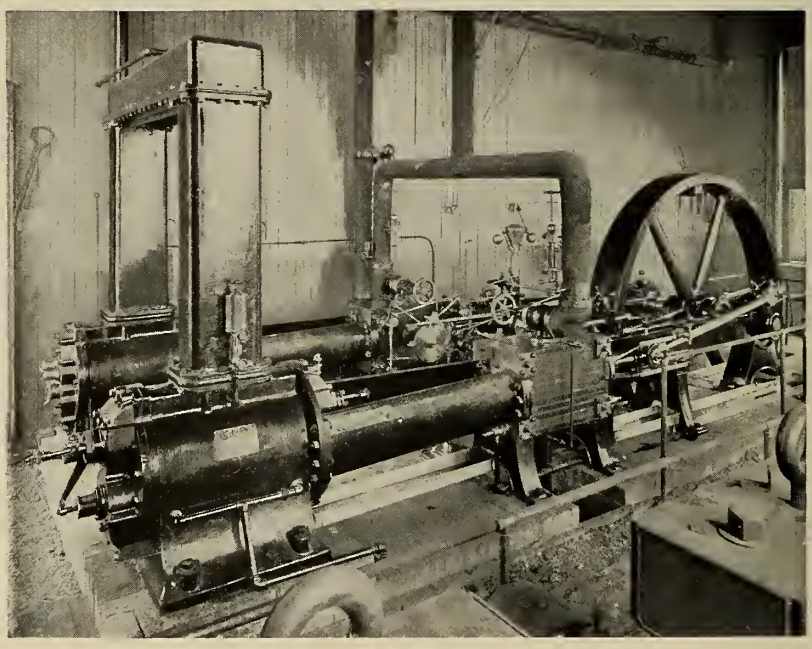
When the preponderance of evidence is for any one of these forms of power it requires no skill to make a selection, but when all things are equal as to cost and maintenance, or nearly so, in bringing any of the powers to the mine, then I wish to show why compressed air should be the choice without hesitation, and after the choice is thus made, how to use it so as to justify the choice.

Compressed air has been abused in its use most shamefully, and until recently none of its friends have been able to be seen or heard, so intensely has the interest of the world been centered upon the marvellous results of the investigation into electrical phenomena. The mysterious has such a fascination for the ordinary mind, and the meteoric developments of electrical science have come so thick and fast, and in so many fields of usefulness, that the average individual could be stampeded into the electrical camp by a mere mention of the name of this most elusive fluid. Now there has come a breathing spell, and the advocates of compressed air are calling attention to the fact that compressed air, properly generated and applied, owns a place in the economics of the day, and this they propose to maintain.

Compressed air has been generally understood to be a most expensive form

of power, and has been given sufferance only because of its utility, since for underground work it really has no rival at any price. Because the laws of compression and expansion of permanent gases belong to the realm of higher mathematics, few understood what they were dealing with, and many of these, unable to overcome the freezing of their motors, did as the public generally did, namely, used the air at practically full stroke, and threw away all the intrinsic pump is equivalent to throttling a head of water to one-fourth of its spouting velocity to accommodate the speed of a wrongly geared water wheel.

I fancy that most of the trouble on the whole subject has arisen from a misconception of what compressed air is in a power sense. Many believe that the power of the engine which compresses the air has been stored in the air compressed, and the more steam they give the engine and the harder it worries and



A DUPLEX CORLISS AIR COMPRESSOR WITH COMPOUND AIR CYLINDERS AND INTERCOOLER, BUILT BY THE RAND DRILL CO., NEW YORK.

energy of the air which we can develop by expansion. Theoretically they thus threw away two-thirds of their power, and, practically about three-fourths. Ordinary direct-acting pumps and rock drills do not have an efficiency of even twenty-five per cent.

No small wonder, then, that the wood piles have dwindled rapidly away and small power results have been produced. Everything was sacrificed to utility, and compressed air did not take its proper rank until engineers began to realise that it must be used expansively. To use air in an ordinary direct-acting flurries, the more work the air should finally yield up. They do not understand that a pound of compressed air at the same temperature contains the same intrinsic energy, no matter what the pressure is, and this is originally contained in the atmosphere before it is compressed at all. This being the case, no matter what power was expended to compress one pound of air to, say, 90 pounds gauge pressure, it will have at the same temperature but one intrinsic potential stored within it. Temperature is the head,—if I may use a term applied to water,—from it comes the pow-

er. If by reason of a physical condition, namely, pressure, one pound of air is allowed to fall from a height represented by a temperature, 60, to one lower, represented by, say, —60, that one pound will generate 184.93 foot pounds of work through every degree it falls, and so on until it reaches —461, the absolute zero, which is the bottom where, in theory, air has neither pressure nor volume, and its work is done. The total intrinsic energy is always 184.93, multiplied by the number of degrees the one pound of air is distant from —461° F.

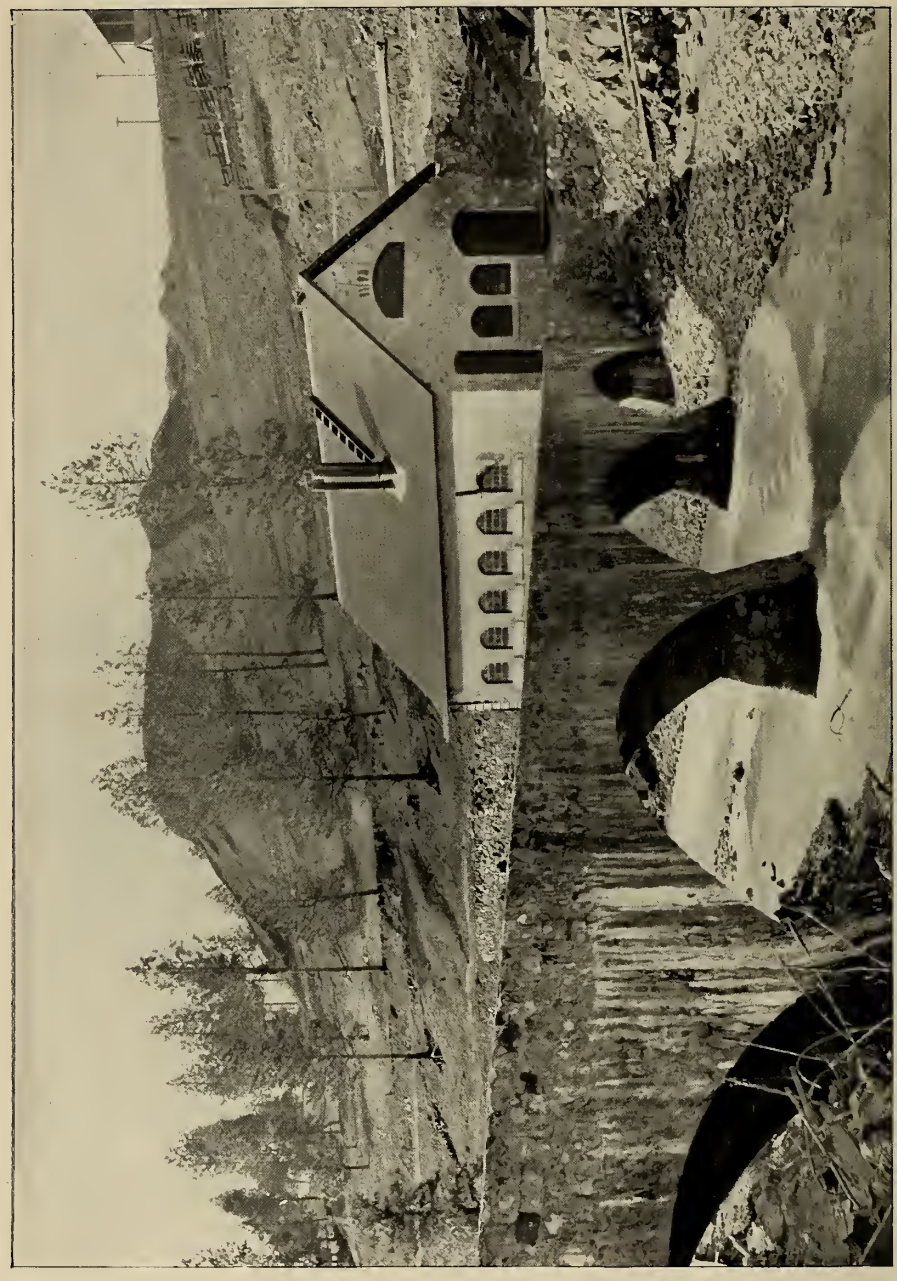
This 184.93 is simply the 778 which represents the foot pounds of work in one British thermal unit, multiplied by 0 2377, which is the specific heat of air at constant pressure—that is to say, it is the fraction of a B. T. U. necessary to raise one pound of air one degree. The quantity of heat therefore necessary to raise the temperature of one pound of air from absolute zero to 60° F., which represents a distance of 521 degrees, will be 184.93 multiplied by 521, which would be 96,348.52 foot pounds, which represents the intrinsic energy of one pound of air at 60° F. This, of course, presumes that no heat will be either lost or gained by radiation or otherwise during the expansion of air, and this sort of expansion is called adiabatic. The centre of earth is the absolute zero of water-power, for there water has no weight. This corresponds to the absolute zero of air, and every pound of water at the same distance, measured in pressure, from the centre of the earth, has the same potential, and independent of its temperature, just as one pound of air has the same potential at the same distance, measured in temperature, from its absolute zero, independent of its pressure.

The sea level for water corresponds to the atmospheric line for air, for at these points neither will manifest motion or power. Suppose the land and water to be on a level, we could not then use any of the potential in the water, unless by some mechanical device we continually created a shaft, whose depth we would call pressure, below the sea level, for the water to fall into and generate power, and it matters not how much power it requires to maintain this shaft at any depth, one pound of water dropping into it will always yield up the same fraction of its total intrinsic potential. The same with air—at the atmospheric line we cannot avail ourselves of its potential, so we use a mechanical device, called a compressor, to prepare a shaft, as it were, which we also call pressure, whose depth we measure in degrees of temperature, and no manter how much power it takes to maintain this condition of affairs, one pound of air dropping into this shaft will always give out the same fraction of its total intrinsic energy.

In neither case does the resultant power depend for its measure upon the mechanical means which cause its activity. Consequently, in compressing air the energy stored in the compressed air is not a definite function of the power required to compress it, but is a definite function of an ideal compression which we call isothermal, with an empirical index.

I have spoken only of the energy *stored* in the air after it is compressed. There is, however, a perfectly mechanical translation of energy from the prime mover to the air motor, that we call the energy of full pressure and is that part of the work performed in an air compressor or given out in a motor which takes place at constant temperature, or, in other words, is the work performed by the piston to discharge the air from the cylinder. I might call it an air piston rod, which reaches from the compressor to the motor, and conveys the energy of one to the other absolutely mechanically, and in the case of isothermal compression would act just the same as if a column of water reached from the compressor piston to the motor piston. It is nothing but a flexible piston rod, acting during the period of full pressure only, and stops when the compressor stops, unless the air receiver be infinite in its capacity.

It is this air piston rod only which direct-acting pumps and ordinary motors and rock drills use, thus avail-

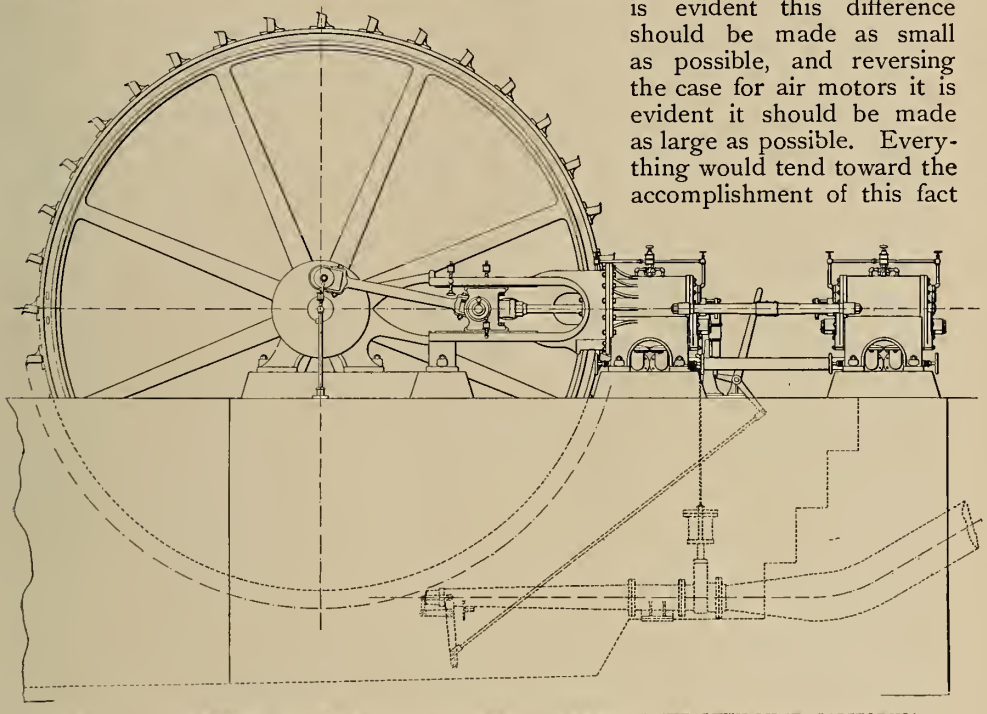


AIR COMPRESSOR POWER HOUSE AT THE NORTH STAR MINE, CAL. THE 20-INCH POWER PIPE IS BURIED IN THE MASONRY OF THE BRIDGE. HEAD OF WATER 775 FEET. COMPRESSOR, 300 H. P. BUILT BY THE RIX COMPRESSED AIR MACHINERY CO., SAN FRANCISCO.

ing themselves of a mere mechanical phase incident to the operation of a compressor and abandoning entirely the real work which is stored in the compressed air itself, and which is practically three times the value of the other. It would be just as sensible to judge the economy of a steam engine by its full pressure work only, as to do so in an air engine.

I have been thus explicit on this somewhat puzzling point because I wish it well understood that the least possible power expended in compression gives the highest resultant efficiency and is the first condition precedent to an economical air plant. To produce this we should use the highest form of prime motor, with proper minimum frictions in all moving parts, slow piston speeds, least clearances, large valve areas and cooling surfaces, so that the heat of compression shall be as nearly constant and at initial temperature as possible, or, in other words, isothermal. It is always a case of temperatures.

Now, in using the air after compression, or, in other words, to utilise as much of its intrinsic energy as possible, we become involved in a case of temperatures again, and it is precisely the reverse in all ways and considerations of the phenomena of compression. If it be true that difference of temperature between the admission and exhaust of the air in a compressor is the head to be overcome by the prime mover in reaching a certain receiver pressure, it is evident this difference should be made as small as possible, and reversing the case for air motors it is evident it should be made as large as possible. Everything would tend toward the accomplishment of this fact readily, were it not for the presence of moisture in the air, which, while it offers no difficulty to compression, which is a heat-developing phenomenon, freezes at once during expansion, which is a cold-producing phenomenon. This freezing has nothing to do theoretically with the perfect operation of the air in its expansion, but practically it fills up the valve ports with ice, congeals the lubricants, and the motor stops. These temperatures range often as low as—150 degrees.



A RIX AIR COMPRESSOR, DRIVEN BY A 19-FOOT PELTON WHEEL AT THE GWIN MINE, CALIFORNIA.

Inasmuch as it matters not between

what degrees of temperature we do our expansion, so long as we maintain the same difference, it must occur to the engineer at once that if, in expanding from atmospheric temperature downward, he meets with the mechanical obstruction of ice, he must slide his range of temperatures up the scale until the final exhaust temperature shall be such that ice will not form. Inasmuch as this cannot be done without supplying extraneous heat, either before or during expansion, the idea of reheating is at once suggested, and upon it hinges the whole subject of the economical use of compressed air.

In determining the amount of heat to be applied to the air before use, it will be found that no great temperatures are required, averaging generally about 150° F. to exhaust at 32° F., to give complete expansion to atmosphere.

Inasmuch as every degree we add to the temperature of the air before use increases its head, provided we exhaust always at the same temperature, and inasmuch as lubricants will not be destroyed at 400° F., or even more, it comes as a natural conclusion that while we are reheating we should go to the practical limit, and especially as it is found by experience that the additional fuel required is of little consequence.

The increase of power obtained by this increase of volume (for that is the way the increased temperature manifests itself) ranges from zero to 60 per cent., at an expenditure for fuel which, after reduction to terms of the prime mover power, means an addition of from zero to ten per cent. of that power, depending upon the head and price of water, or price of fuel. A gain of fifty per cent. at an expenditure of ten per cent. may in some cases be made to cover all losses of compression and transmission, and deliver to the motor the full amount of power expended upon the air at the compressor, or even more.

It need not be demonstrated here that the use of fuel to expand air is from five to seven times more economical than in any other manner to generate power.

The motor is the last thing, and the most important thing, to be considered. Inventors and builders of compressed air machinery are apparently devoting too much time to the compressor and none at all to the special air motor. Compressors can be made having an efficiency approximating ninety per cent., while the average motor using the air from such a compressor would not give forty per cent.

The advocates of compressed air would gain several points if they would pattern after the methods of electrical engineers, who have claimed from the very beginning that nothing was too good in the shape of material or machinery for the development of electrical power. The very finest and most efficient prime motors are always insisted upon, even down to insignificant plants, and the splendid construction of generators and installation of machinery and appurtenances almost without regard to cost, has enabled them to place their product upon a high engineering plane. Their methods and their ideas for the advancement of their interests have been correct, and they are justly entitled to a commensurate reward.

How all this contrasts with the miserable class of compressed air machinery which until the last twelve months has been installed in different places! The very cheapest of slide valve engines, or some jumping, flapping belt for prime movers; poorly designed, poorly made compressors, with insufficient valve areas and cooling devices; generous clearances; enormous piston speeds; all and everything done to make a machine as cheap and undesirable as possible. For motors, anything that would reciprocate; the valve motions causing the pistons to meter out nicely the air in solid chunks at full pressure; the real work being done at the end of the exhaust pipe; and I might add that the louder the noise of escape, the more work was supposed to be done in the cylinder, whereas in reality the air was simply making a louder protest at its misuse.

All this must change, and is changing, and an awakening is at hand. It is the duty of every pneumatic engineer to insist upon high-class installations,

not only for his personal success, but for the advancement of compressed air.

The requirements of the ordinary mine in California, for example, as far as power is concerned, may be enumerated as follows:—Power for hoisting, for both surface and underground pumps, for rock drills, for milling and for lighting, for forge blasts and the mine whistle, which must be provided for some way, as it serves to mark the shift changes and give the fire or accident alarm.

I will take up each of these heads, briefly; speak of the prevailing practice and how it can be improved; and in any comparisons I may make between the efficiency of compressed air and any other power, I shall assume that the horse-power in each kind of power costs the same, ready to deliver to the various motors.

Before speaking of the various motors to develop the required power, we shall assume that the mine is properly equipped with air conduits and reheating apparatus. Too much stress cannot be laid upon the fact that generous air conduits on the surface and underground, properly provided with bends or elbows of large radius, and properly insulated where they convey hot air, contribute greatly to the economical operation of an air plant.

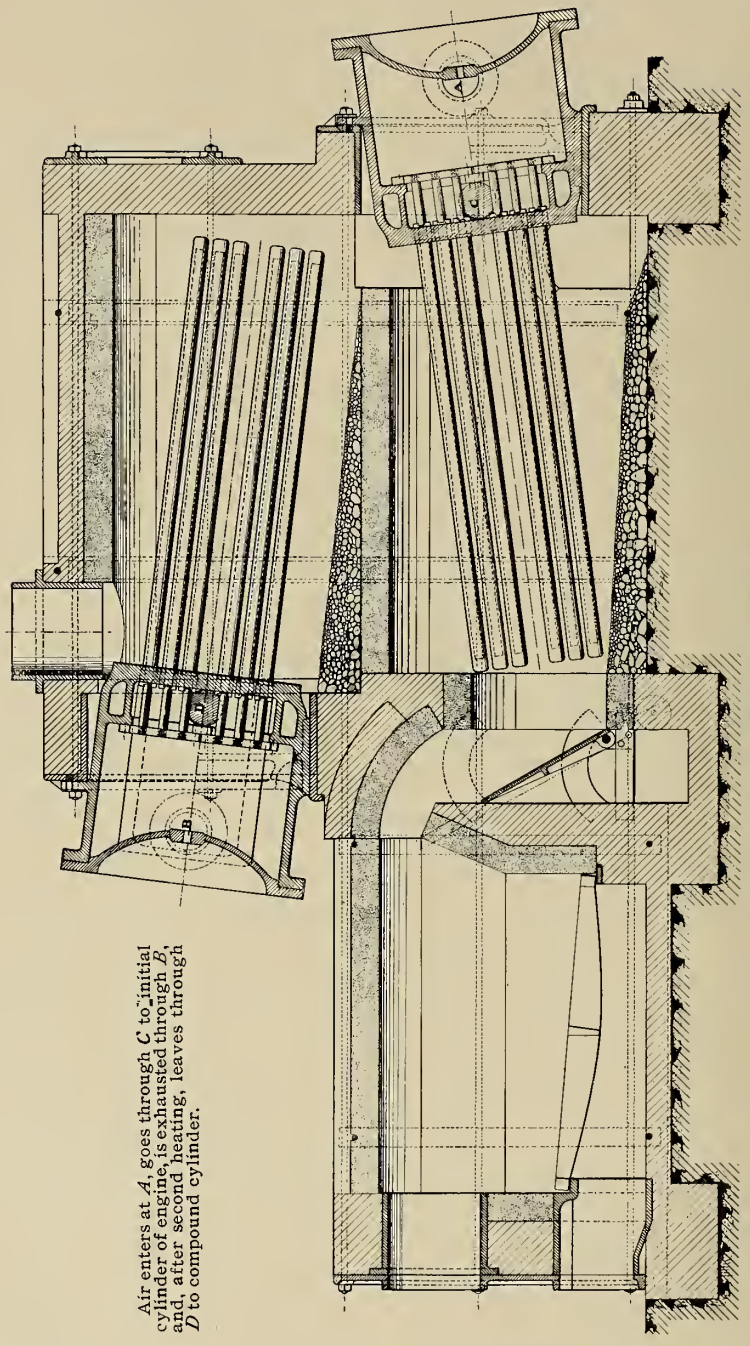
While the actual loss to the compressed air in its potential, by the drop in pressure, caused by friction in small pipes, is not more than one-third of what the public believes it to be, still the annoyance in not getting initial pressure where small working cylinders are used, is great; and again, the increased velocity in small pipes down a shaft, deprives the compressed air of a gain of power as it goes downward, which it would have in proper-sized conduits.

Illustrating the first point, it is generally assumed, for instance, that if a compressed air pipe receives air at 100 pounds and delivers it at 80 pounds, the loss is twenty per cent. So it is, in pressure; but relative pressures do not measure such a loss, for while the pressure has decreased, the volume has correspondingly increased, and the real loss is merely a frictional one of 8.4 per cent. instead of twenty.

Illustrating the second point, there is a very material gain to be had from the weight of air in average shafts, provided the pipes are of proper size. Air at 90 pounds gauge on the surface would be 92 pounds at 500 feet, 94 pounds at 1000, 96 at 1500, and 98 at 2000 feet, —a gain sufficient to offset all frictions and ordinary leakage, a proportion which cannot be matched in electrical transmission down a shaft.

Most of the air plants in mines are inefficiently piped, and no attention whatever is paid to long bends, and the pipes in general appear to be specially installed to exhibit every class and variety of pipe fitting the market affords, and with many duplicates. I have counted five 1-inch elbows in the space of three feet, to connect up a pump to the main air pipe, when the price of 1-inch hose and couplings would have been less and the hose would have delivered to the pump nearly the line pressure. The pressure loss in each of the 1-inch elbows would be five-thousandths of the square of the velocity of the air through the pipe. The pump had a 6-inch cylinder and the piston moved fifty feet per minute. The ratio of the cylinder area to the pipe being 1 to 36, the air in the pipe must move 1800 feet per minute, or 30 feet per second. This squared and multipled by five one-thousandths makes a loss of 4½ pounds for each elbow, or 22 pounds for the five, certainly not a sensible or desirable result, yet one sees it everywhere in the mines. The passion that miners have for 1-inch pipe is marvellous. One may frequently see strings of it five hundred feet long, conveying air. It has cheapness and ease in installment to recommend it, but the wood pile and the owner suffer. A proper plant should have no 1-inch air pipe underground over ten feet long, and no short elbows.

At some convenient place, where the total length of air conduits from the surface motors shall be a minimum, a good reheater should be established and connected to all these motors. There is



A RIX COMPOUND REHEATER.

Air enters at *A*, goes through *C* to initial cylinder of engine, is exhausted through *B*, and, after second heating, leaves through *D* to compound cylinder.

ample scope to improve upon the reheaters now upon the market. They may be classed as coil, tube and shell reheaters. The first is a simple coil or nest of coils within a furnace; the tube reheater consists of a nest of pipes screwed into a cast-iron head, and all surrounded by a furnace; while the shell reheater is made much like an ordinary domestic sheet-iron heater, except that it will sustain pressure, the fire being within it.

Any of these will do fairly well, especially if well insulated on the outside to prevent surface radiation. They should be provided, in large plants, with pyrometer and proper dampers, to prevent overheating. There are also compound reheaters which contain two independent heating compartments for different pressures, the utility of which will be seen later on.

A very small amount of fuel will be used in one of these reheaters—just about half a cord of pine wood a day, to reheat 100 horse-power of cold air so that it will yield 140 horse-power. When it is remembered that one-half a cord of pine wood will yield at the maximum 8 horse-power for twenty-four hours, when burned under a steam boiler, its capacity to produce 40 horse-power is little short of incredible. Besides doing this, it renders still further service by permitting us to use the compressed air in an expansion engine.

Some engineers use a steam boiler for a reheater, especially if it is already installed at the mine. A slow fire is maintained on the grates, and about eighty to ninety pounds steam pressure maintained; the compressed air bubbles up through the hot water and mingles with the steam. Fully ninety per cent. of the mixture is air. This system has earnest advocates who claim that the latent heat of the condensing steam being released in the motor cylinder just where it is then needed, and the condensed water acting as a lubricant, make this system preferable. It is certain that the heat can be carried farther this way, but the classes of dry reheaters mentioned first are simpler, will give higher temperatures, and require less fuel.

A temperature of 450° F. can easily be maintained in the dry reheater, and with well insulated pipes this will insure 400° F. to all motors contained within the ordinary hoisting works with mill adjoining.

There should be installed, at the end of the compressed air transmission pipe, ample reservoir capacity. This is, next to reheating, the most important feature in a compressed air plant for mining work, and it is in the proper arrangement of this particular feature that a great gain in economy may be secured over electrical power for intermittent work.

The two sets of machines which take the most power around a mine are the rock drills and the hoists. These use large powers for short periods, and frequently the average power covering twenty-four hours is, in the case of the hoist, from one-third to one-fourth the maximum, and with rock drills about one-half, where more than three machines are in use. It is evident, therefore, that if sufficient storage capacity be provided, the average power only will be demanded from the transmission main, while in an electrical plant the maximum power is generally delivered by the transmission, for it may be required at any moment. This makes it an expensive proposition to use electricity for intermittent work.

As an instance of the relation of storage to intermittent work I will cite the case of the Banner Mine, at Oroville, California, which has a compressor with a single double-acting 10½ by 12-inch air cylinder; the piston runs at 300 feet per minute, and the machine is probably delivering 150 cubic feet of free air per minute. This size of machine is rated by builders as a two-drill compressor, yet it is driving two 3⅛-inch machines, one 3½-inch, one 2¾-inch, and, on occasion, a 2-inch also. The united requirements of these machines, should they be running at the same time, would be 285 cubic feet per minute—almost double the output of the compressor. The explanation lies in a very large and unusual reservoir capacity—in fact, ten times larger than

ordinarily employed with a compressor of that size. The wisdom and economy, however, of such large receiver capacity is apparent, and this example should be followed, especially as receivers are very inexpensive.

As an example of the advantage of reservoir capacity with a hoist, I call attention to the hoist at the North Star Mine, Grass Valley, which develops 80 to 90 horse-power when running, but calls on the compressors to exert but from 25 to 30 horse-power to maintain it.

Receivers should be placed at any general distributing point in the mine, as well as upon the surface. Any one managing a mine, by keeping a record for two days only, of the length of time his intermittent machines are running during the day, can readily calculate the proper receiver capacity required.

Coming now to the machinery proper for the mine, first in order of installation is the hoisting works, which we will consider only from the standpoint of economy and utility. It is supposed, of course, that the elements of strength, safety, capacity and everything, have all been properly considered by the designing engineer. It is almost a rule that a mine that can afford to have an economical transmission plant has use for a hoist of sufficient capacity to enable it to be one of the highest motor type, and for this purpose I shall install a compound hoist, direct-connected—that is to say, there will be no gearing whatever on the hoist, the shaft carrying the drums being at the same time the engine shaft, and the cylinders proportioned with reference to the initial and final pressures desired, and also with respect to the amount of expansion done by reheating. To get the largest amount of work from a hoist of this character, the air should be reheated to about 400 degrees before passing into the initial cylinder. It will be exhausted from there back into the second compartment of the compound reheater, and heated again to 400 degrees; from there it will pass to the low-pressure cylinder, perform its work and be exhausted to the atmospheric pressure.

It does not require any particular amount of calculation to show that with this double reheating the volume of the air may be practically increased from sixty to eighty per cent., with a corresponding degree of economy. For the second reheating practically no extra fuel is required, the second reheater being placed above the first one and absorbing the heat after it has passed through the first series of tubes.

A hoist of this character will be found much easier to care for than one operated by steam, for there will be no condensed water to be carried off, and the machine is ready to start in operation at a second's notice. There is no other manipulation, as far as the motive power is concerned, except the opening of the throttle valve.

In the operation of a hoist of this character the service of storage reservoirs in conjunction with compressed air use becomes very apparent, and, as stated before, a hoist which requires from 80 to 100 horse-power to operate while it is in service would, in the average mine, require but 25 to 30 horse-power at constant work delivered by the compressor. The advantage of this is apparent, and while it is approached by steam power, cannot be matched by any other service excepting by a water wheel plant having large reservoir capacity.

The next surface motor of importance around a mine will be the mill engine, which, as a general rule, has a constant load. It is only in the smaller mills that the power required for the rock breaker is intermittent, but in such a plant as we have been considering, the rock breakers will probably be of such size that they can run continuously from the ore bins, which will render the total power required from the mill engine a constant.

In this case, for compressed air the engine will probably be, for ordinary purposes, a straight-running simple Corliss engine, using reheated air. If the mill requires considerable power, it would be advisable to install a tandem compound Corliss engine, where the air will be reheated twice, as in the case of the hoisting engine.

Compressed air can claim no particular advantage over electricity in its economy for driving this constant load, nor, for that matter, over a high efficiency water wheel or a compound condensing steam engine. The honours are practically easy all along the line.

The general system being compressed air, therefore, there is no loss or disadvantage in using it for the constant load. The same course of reasoning will apply to engines which may be used for driving Cornish pumps from the surface, or any other constant load requirement, such as driving fans or tramways. For intermittent work, such as a sawmill, in connection with a mine, compressed air would have the same economy with a properly designed motor as for the hoist.

Outside of the requirements heretofore mentioned, the only other required service would be for furnishing lights. For an ordinary mine 10 or 15 horsepower would readily supply this. Compressed air, of course, will have to be transformed, through an air motor and dynamo, into electricity, for furnishing lights, and this naturally must be at considerable loss, and in this instance furnishing the electric current direct would be very much more economical; but the amount of power required for this service is so insignificant, in reference to the balance required by the mine, that it need not be seriously considered.

For underground work practically but three kinds of service are required—hoisting from winzes, running of rock drills, and pumping.

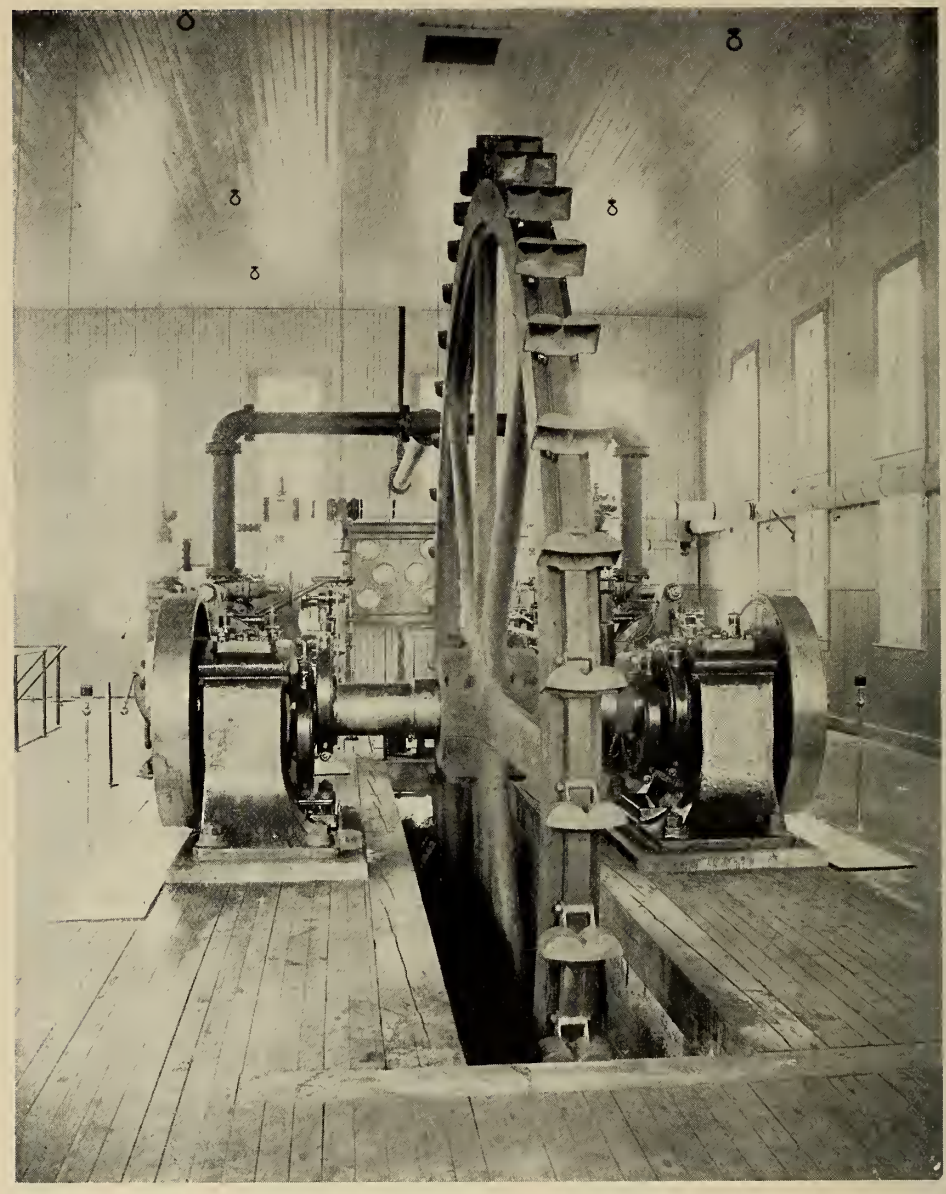
Owing to the fact that, as a general rule, it is not desirable to place large or expensive hoisting plants under ground, the character of the engines used is not very economical, but the work is so intermittent in its character—much more so, as a general rule, than the hoist on the surface—that even these uneconomical engines can be operated with compressed air at much less expense than by electricity. In many cases it is desirable to reheat this air, which can be done with perfect ease, either by means of an externally fired furnace, using either wood or coal, where an old shaft or a proper system of ventilation will take away the gases of combustion, or the air may be heated by an internally fired furnace, in which coke is placed at proper intervals of time in sealed chambers made to withstand the air pressure, and through which the compressed air passes, furnishing oxygen for the combustion. The writer is now making some installations for underground reheating, using kerosene and also distillate. Recent burners made for the consumption of this oil afford a smokeless and odourless combustion and give an intense heat at a very small quantity of fuel consumed. It is entirely probable that they will prove satisfactory and be easy to manage.

It is always well in installing underground hoists of all kinds, to place in close proximity as large a reservoir capacity as possible.

For underground pumping, ordinary direct-acting steam pumps, using air instead of steam, are the most uneconomical machines that can possibly be employed in the use of any power, and should never be used unless their utility more than counterbalances their wastefulness of power.

For a properly operated mine, having a considerable quantity of water to pump, a station pump, with compound engines using reheated air, will give the greatest economy. When it comes to the subject of rock-drilling, which forms, as a general rule, two-thirds of the power required underground, compressed air has the field all to itself at present, and here utility alone is considered, for rock drills are as uneconomical in the use of air as a direct-acting steam pump. Still, they do such a tremendous amount of work in comparison to the cost for operating them that their economy is measured only in the amount of rock or ore which they are instrumental in extracting, and not in the power which is required to drive them.

It is evident, however, that it will take less power to furnish air for these machines if such air is taken directly from the transmission main than if it



A RIEDLER COMBINED STEAM AND WATER POWER COMPOUND AIR COMPRESSOR AT THE ALASKA TREADWELL MINE.—PELTON WHEEL, 22 FEET DIAMETER.

were furnished at the surface by water-power or electrical or steam motor. Besides, a considerable portion of the cost of furnishing compressed air to these machines is offset by the pure air which is furnished to the miners underground and the readiness with which it blows the smoke, caused by blasting, from the various underground workings. For underground work it is also valuable in case of accident, and an air pipe leading back into a drift, a portion of which has caved and imprisoned miners beyond, has not only furnished them pure air, but at the same time these pipes have given a means of communication with those outside.

As far as first cost is concerned, the

average of a number of costs of installation which have come to my knowledge show me that the air plant is from twenty-five to fifty per cent. cheaper, depending upon the nature of the installation, the amount of power and the distance of the transmission.

As a general rule, the ordinary free gold milling mine in the State of California on a working basis would require motive power, divided up nearly as follows:—25 per cent. for the mill, 32 per cent. for the hoisting, 5 per cent. for direct-acting pumps, 10 per cent. for station pumps, 23 per cent. for rock drills, and about 5 per cent. for lights.

Allowing that electricity to the amount of this 100 per cent. has to be purchased to operate this mine, using compressed air according to the manner that I have mentioned, would probably call for only about 74 per cent. in comparison, divided up as follows:—25 per cent. for the mill, 10 per cent. for the hoist, 3 per cent. for the direct-acting pumps, 13 per cent. for the station pumps, 16 per cent. for the rock drills, and 7 per cent. for the lights.

For quarrying work it has been found recently at Jerome Park, in New York, where a very excellent compressed air plant has been installed, that they are operating hoisting engines and rock drills very much cheaper by compressed air than they formerly did by steam.

Statements are made, which I have no means of verifying, that it is done with one-half the coal formerly required when steam was used direct. The contractor is making a large excavation, covering probably a square mile in extent, for a reservoir. He has established in the centre of the work a 500 horse-power air compressor, and is driving fourteen hoisting engines and fourteen rock drills at various parts of the work, and reheating the air prior to its use in the hoisting engines.

These results seem to point to the fact that where steam, directly generated, cannot compete with compressed air, it is useless for any power to try to do so under the same conditions. It all lies in the fact that the work is intermittent and that is the principal claim made on this present occasion, that in determining the character of the power to be selected for any kind of an operation many things besides the efficiency of the apparatus at full load and constant operation, are to be considered.

Very frequently a compressed air or water-power plant, capable of storage capacity, would be more economical to use at a constant load efficiency of fifty per cent. than any other power at a constant load efficiency of ninety per cent. It is like the cost of a manufactured article—it matters very little what rate of wages is paid, provided the amount of wages which enters into the cost of the product be satisfactory. So it is in a power proposition—it is not the efficiency of five minutes' operation, it is the total cost covering twenty-four hours.

From an engineering standpoint, if one were asked the most economical steam motor to operate an electric street railway plant, one would probably say, a compound or triple expansion Corliss engine, running condensing. But this depends entirely upon the cost of the coal, for the difference in interest and depreciation between a condensing plant and a simple high-pressure plant will sometimes more than offset appreciable differences in the fuel item. This is an instance where high efficiency engines are not engines of great economy, and I have been particularly emphatic upon this point, because compressed air has suffered much on account of improper comparison with electricity in this manner.

We all know that electric generators and motors have been constructed that will give an efficiency of from ninety-two to ninety-five per cent. at full load, while compressed air generators and motors fall below these figures in mechanical efficiency, but in practical economy for such work as we have had in consideration, I claim twenty-five per cent. superiority in economy over electrical installation. Mechanical operations are not conducted for amusement, but for profit, and that operation which produces equal results with another, for a less monthly or yearly cost, labour,

material, fuel or power, interest, depreciation, etc., all being given their proper value, is the more economical.

I claim that compressed air, for intermittent work (which is fully fifty per cent. of all work done by motors), has no rival for general economy or utility, and particularly is this true for mining work. It must always be borne in mind that economy in compressed air depends upon reheating, and then expansion, and my remarks are not directed toward that class of compressed air motors which use cold air or air at full pressure.

Utility very frequently overbalances considerations of economy or efficiency, as may be illustrated in the air brakes which are attached to locomotives throughout the world. These air brakes are most uneconomical in the use of steam, using it practically at full pressure, and are about the same class of motors as the direct-acting steam pumps which have an efficiency of only about twenty per cent. as compared to a high-class steam motor. I have heard it stated that there are 20,000 of these air-brake motors working in the United States alone, absorbing about 10 horse-power each, making 200,000 horse-power devoted to this appliance alone, which completely overshadows all the rest of the compressed air installations in the United States in magnitude, and yet no one hears of any one attempting to replace this very inefficient motor with any other more efficient appliance for generating compressed air, for its utility is such and there is so much dependent upon it, that economy is a secondary consideration.

A SHORT TALK ON PATENTS.

By E. H. Mullin.

THOMAS A. EDISON is naturally genial and good-natured in conversation, except when the subject of patent procedure in the United States happens to come up for discussion. Then, with appropriate gesture and emphasis, he denounces United States patents as the most worthless and most annoying things on the face of earth, and declares that if he had his life to live over again he would protect his inventions by secret process and take his chance of the result.

This declaration comes all the more curiously from Mr. Edison's lips because more patents have been issued to him by the United States Patent Office than to any other inventor, either alive or dead. Nor is Mr. Edison one of those unpractical geniuses who invent perpetual motion machines, or emergency brakes for stopping railway trains suddenly by gripping the rails, or machines for melting snow which will be cheaper than carrying it off into the next county in wheelbarrows; on the contrary, his patented inventions, particularly in the domain of electricity, have brought him in a large fortune. Moreover, he has no grudge against the present commissioner of patents or any of his predecessors; the United States courts have usually affirmed the validity of his patents, so that he can have no spite against them. What Mr. Edison really seems to object to is the fact that while the Constitution of the United States provides that, "the Congress shall have power to promote science and useful arts by securing to authors and inventors for a limited time the exclusive right to their respective writings and discoveries," the only right which the grant of a patent confers is that of bringing suit in the Federal courts against an infringer.

Such a suit may take anywhere from three to ten years to reach the court of last resort; it allows the infringer, besides pleading that his apparatus does not infringe on the patent in question, to show that the patentee was not the original inventor, or that he abandoned his invention to the public before taking out a patent, or that his proceedings were not properly carried on in the Patent Office; and if any of these contentions are found true in fact, the patent will be declared void by the court, while if the patent is sustained on all issues, an injunction will be issued against the infringer and damages may be given for past infringements.

All this costs a great deal more money than is generally recovered from the infringer. First-class counsel and expert witnesses demand very high fees, and the bill for searches, models and the printing of long briefs and exhibits must often amount to thousands. It is quite evident that a poor man who makes some great patentable discovery has no chance at this game without the aid of men with large capital, who generally take the lion's share of the profits for their assistance.

If a patent in the United States were like a will, so that all the infringers might be joined together as defendants and its validity established by a single

suit Mr. Edison and other less fortunate inventors might bear their troubles cheerfully as indispensable evils; but, instead of that, infringers may pop up in any one of the nine judicial circuits intowhich the United States are divided, and, as the defendant in any suit must be tried at home, there may be several suits going on at the same time. Moreover, each of the twenty-two Circuit Court judges may act as seems good to him, granting or refusing a preliminary or a temporary injunction against the infringer until the final adjudication of the suit establishes the validity of the patent and the fact of its infringement, or declares the patent void.

In order to relieve the Supreme Court of some of its work the United States Congress passed a law, a few years ago, making a new tribunal, known as the Circuit Court of Appeals, whose decision is final in patent cases. But as there are nine of these tribunals, a bold infringer, beaten in one, will try another, and sometimes obtain a conflicting verdict, so that, after all, the case goes before the Supreme Court for final decision.

Patent laws in the United States have undergone three transformations. The first two laws, passed in 1790 and 1793, followed the British practice as it then was. The next act, passed in 1836, was a comprehensive, well drawn statute, which has since served as a model for other countries. Its chief provision was that the commissioner of patents should cause each application to be examined and if it had the essential elements of novelty and utility, he had no option but to issue the patent. This is substantially the British law of to-day, which tends to make the issuing of a patent on anything patentable a mere matter of registration fees, leaving the question of infringement and validity to be decided by the courts of law. The third great patent act in the United States, passed in 1870, gives the commissioner a certain amount of discretionary power by commanding him to issue a patent to an applicant if he finds him "justly entitled" to it.

A staff of patent examiners is provided to compare all applications with previously granted patents or applications on file, and one of these examiners decides in the first instance whether or not a patent shall be issued, though an appeal lies from him to the commissioner. It has happened more than once that these examiners have taken several years to decide whether a patent should be issued or not. Thus it took the commissioner and his staff fourteen years,—from 1877 to 1891,—to decide that Emile Berliner was entitled to a patent for his improvement of the telephone.

If such long examinations saved the courts of law any work they might be justified, but considering, as said before, that all the Patent Office does is to give an inventor a *prima facie* title, the present law should be amended so as to require an application for a patent to be definitely accepted or rejected within six months from the time it has been filed.

The German patent law is usually considered the fairest in the world for inventors. The patent runs for fifteen years, and the invention must not have been described previously in any way in a printed publication. No patents are issued for chemical compounds or combinations, and, as a rule, improvements in detail must be added to the original patent and expire with it. The fees are $7.50, or about £1. 10. 0. on the granting of the patent, and $12.50, or £2. 10. 0. for the first year, double this amount for the second year, treble for the third year, and so on, until the patent expires. If the invention is not carried out during the first three years, the government may revoke the patent. The best of the German law, however, remains to be told. The government, having once granted the patent, undertakes to defend its validity and to follow up infringers at its own expense, and thus puts the poor inventor on an equal footing with the rich one.

The patent laws of Great Britain embody a useful provision to prevent capitalists from buying up patents and keeping them inoperative in order to prevent the depreciation of existing plants. The

British Board of Trade is empowered to grant licenses to persons who are able to show that the patent is not being worked in the United Kingdom, or that the reasonable requirements of the public are not being supplied, or that any person is prevented from working or using to the best advantage, an invention of which he is possessed.

The patent laws in Great Britain work out much better in practice than those in the United States. A patent case is first thrashed out before one of the equity judges of the High Court of Judicature, after which it may be taken by the loser before the Court of Appeal. With the record of a Court of Appeal decision in favour of a patentee before them, British judges give short shrift to new infringers. Counsel for the infringers, who attempt to go into questions already judicially decided, are sternly cut short and asked if they have any new defense to offer. If not, a permanent injunction and a strict accounting is granted at once.

A couple of years is usually sufficient to put the owner of a valuable foundation patent in a position to mete out swift and certain punishment to wilful infringers. As far back as 1759, James Watt was able to collect the royalties due to him by a formidable combination of infringers of his patent for an improved steam engine by the single judgment in the case of Boulton & Watt against Bull, and it is equally true that American inventors, like Graham Bell and Edison, have had far less litigation over their British than their American patents. Perhaps the most humiliating episode in the history of the United States judiciary was its failure, in spite of well-meant efforts, to secure to Eli Whitney some of the fruits of his invention of the cotton gin. He was declared the true inventor and patentee of this machine, but he died in abject poverty, with the judicially declared infringers of his patent making millions on every side of him.

Nothing was ever more clearly proved and more frequently affirmed than that Alexander Graham Bell had a seventeen-year's right to the reproduction of human speech through an electrified wire. Yet his title to his invention was attacked by hordes of would-be plunderers from the day it was seen that the telephone would be a commercial success until the foundation patent expired in 1893. If the United States Congress will not pass efficient laws "to secure to inventors for limited terms the exclusive right to their patents," the Federal judges still have it in their power to make wilful infringement so expensive a luxury that it will no longer pay to infringe, as it seems to do now.

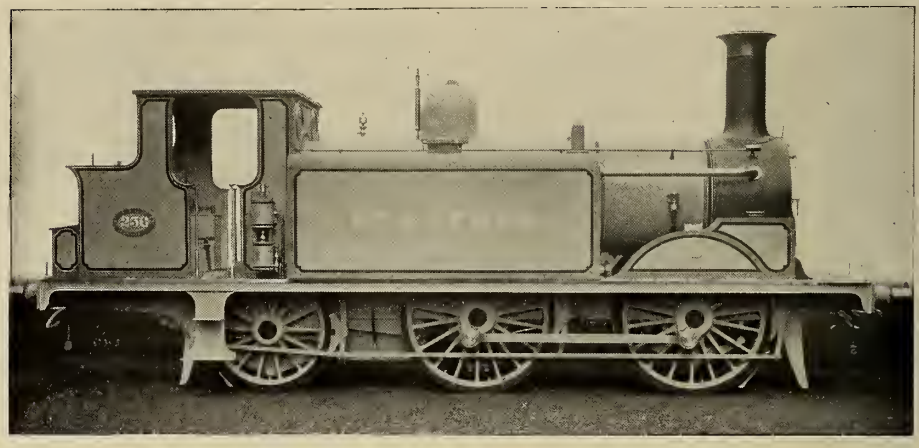
TYPES OF BRITISH TANK LOCOMOTIVES.

By A. E. Kyffin.

UPON examining British railway systems the first thing likely to attract the attention of an American would be the immense number of short branch lines and the network of suburban lines in and about the great towns, London especially, where an enormous amount of suburban traffic is carried on. Large tender engines are not very well suited to this work, for the amount of time wasted in turning these would be excessive. Tank engines run in either direction with equal facility and less space is occupied with them than would be by tender engines.

Thus upon examining the locomotive stock of the various companies a large variety of tank engines present themselves, each type brought into existence by force of circumstance or the engi-

A MIDLAND RAILWAY TANK ENGINE.



A LONDON, BRIGHTON AND SOUTH COAST RAILWAY TANK ENGINE.

neer's opinion as to the most suitable type for a certain road. They can roughly be separated into three different classes according to the work for which they are intended, namely, passenger, mixed traffic and goods engines.

As to the merits of the tank engine as a fast runner, many companies haul express suburban trains with them at a very creditable speed indeed, and in special cases mail trains and expresses have been worked by them; but this is not the rule, for the trains run by tank engines are not often booked to run much over 50 miles an hour. Speeds of 70 miles and upwards, however, are not uncommon down hill and on the level.

Eleven types have been selected as representing the usual practice and as giving a fair idea of the proportions followed generally in Great Britain; the question as to the merits or demerits of each class is not within the scope of this article, which is intended merely to give the reader some idea of the locomotives working the short distance and suburban trains on British railways.

For passenger work exclusively the type of engine most favoured at present

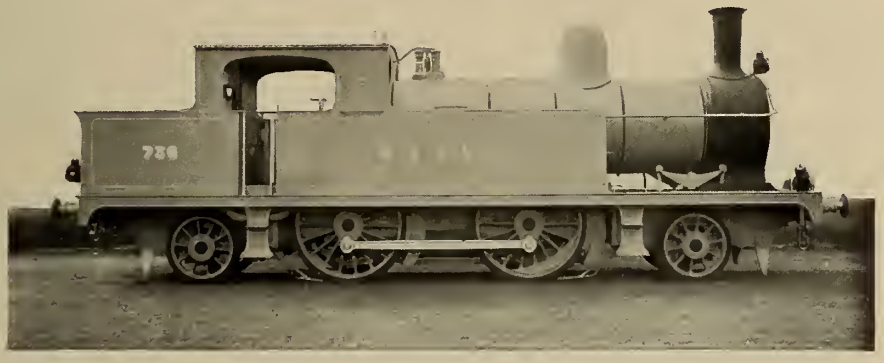
is the eight-wheeled type with a bogie under the trailing end. Most companies possess engines of this type, as the coupled wheels are, as a rule, of considerable size, varying from 4 feet 9 inches to 5 feet 8 inches in diameter, and the engines are, therefore, suitable for running short-distance fast trains. They are also very free in starting away from stations. A good representative of this class is shown on the opposite page. This type was first introduced on the Midland Railway, in 1870. The old engines were absolutely innocent of a cab, a weather board only being provided. The modern engines have cylinders 18 by 26 inches, the coupled wheels being 5 feet 3½ inches. Some of this class work in the tunnels of the Metropolitan Railway, and therefore have the condensing apparatus shown in the engraving.

Next to the trailing bogie tank, the eight-wheeled double-ender is perhaps the most extensively used, five of the largest companies in Great Britain alone employing it. Having a radial axle at either end, the running is as easy one way as another. Some very creditable work is done by engines of this type. The coupled wheels are usually about 5 feet 6 inches in diameter, and speeds of a good deal over 60 miles an hour can be attained without an undue amount of oscillation.

The Manchester, Sheffield and Lincolnshire Railway works its suburban trains almost exclusively with this class. These particular engines have one peculiarity for British practice, namely, the Belpaire firebox. The company just mentioned is the only one at present having this form of firebox as the standard, and the engines are proving very satisfactory; the coupled wheels have a diameter of 5 feet 7 inches, the loaded weight being 59 tons. The London and North Western Railway have a small class of this type with 4 feet 6 inch coupled wheels and cylinders 17 by 20 inches.

One of the oldest types of passenger tank engines is the eight-wheeled, leading bogie, outside cylinder type, introduced by Mr. William Adams on the North London Railway in the fifties. These old engines had a four-wheeled bogie, inside cylinders and four coupled wheels 5 feet 3 inches in diameter. The bogie was pivoted behind the smokebox tube-plate, so that, although on eight wheels, the total wheel base was only 16 feet 3 inches; later the cylinders were placed outside the frames, and in this condition, with detail alterations, the engine has remained the standard type on this line; the modern stock has 17½ by 24-inch cylinders, coupled wheels 5 feet 6 inches in diameter, with a boiler pressure of 180 pounds per square inch.

Engines of this type were designed by Sir John Fowler for the Metropolitan and Metropolitan District Railways,



A EIGHT-WHEEL DOUBLE ENDER ON THE MANCHESTER, SHEFFIELD AND LINCOLNSHIRE RAILWAY.

and for many years were the only class, to be seen on the trains of those lines. The "inner circle" is thirteen miles long, and there are twenty-seven stations, a little over an hour being occupied by the journey. These engines have condensing apparatus; the cylinders are 17 inches by 24 inches; the coupled wheels are 5 feet 9 inches in diameter, the loaded weight being 46 tons 10 cwts., of which 35 tons 3 cwts. are carried by the coupled wheels. Representatives of this class, only with inside cylinders, are to be found on several lines.

A class of larger tank engines,—a development of the above mentioned type,—was introduced on the London, Tilbury and Southend Railway in 1880. These engines have ten wheels, a leading bogie, four coupled wheels and a pair of trailing wheels with radial axles. The cylinders are placed outside the frames and are 17 by 26 inches. Their work comprises every class of train handled by this small company, but as several of its trains are timed to run the 36 miles from London to Southend in 50 minutes the wheels are of considerable size, being 6 feet in diameter. Excellent running is performed by this class, high speeds being common. The weight of these engines in working order is 55 tons 11 cwts. 3 qrs., of which 32 tons 1 cwt. are carried by the coupled wheels. In the latest development of this class, the wheels are no less than 6 feet 6 inches,—a hitherto unheard-of size for a side-tank engine. This type, with inside cylinders, seems to be growing in favour, several of the Irish railways having adopted it for branch line trains.

A type of tank engine which at one time prevailed to a considerable extent, but is now giving place to the trailing bogie tank, is that represented by the London, Brighton and South Coast Railway's engine. The coupled wheels are 5 feet 6 inches in diameter, the cylinders 17 inches by 24 inches, and the weight loaded is only 38½ tons, so that with a light weight there is combined considerable power. Another serviceable class for light trains and short distances is the six-wheeled tank engine with four coupled wheels behind and a radial in front. The North Staffordshire Railway,—a short line with a heavy local traffic in the Midlands of England,—employs this class as its standard for local passenger traffic. The trains are not very heavy, so that great power is not required. The Great Western Railway also uses this class for its passenger traffic, but the wheel base is rigid, outside axle boxes being provided for the leading axle.

MIXED TRAFFIC TANK ENGINE ON THE TAFF VALE RAILWAY.

The six wheels coupled type is not used by many lines for passenger traffic,

A PASSENGER TANK ENGINE ON THE NORTH STAFFORDSHIRE RAILWAY.

but on two lines at least they fill a very important position on the local trains. These lines are the London, Brighton and South Coast and the Great Eastern Railways. To the Brighton company belongs the honour of introducing the type for passenger service. It was in 1872 that the first of these now celebrated engines was built. They are very small, the wheels being only 3 feet 10 inches in diameter, with cylinders 13 by 20 inches. The wheel base is but 12 feet, the weight in working order being 25½ tons. For starting away from stations few classes can excel them.

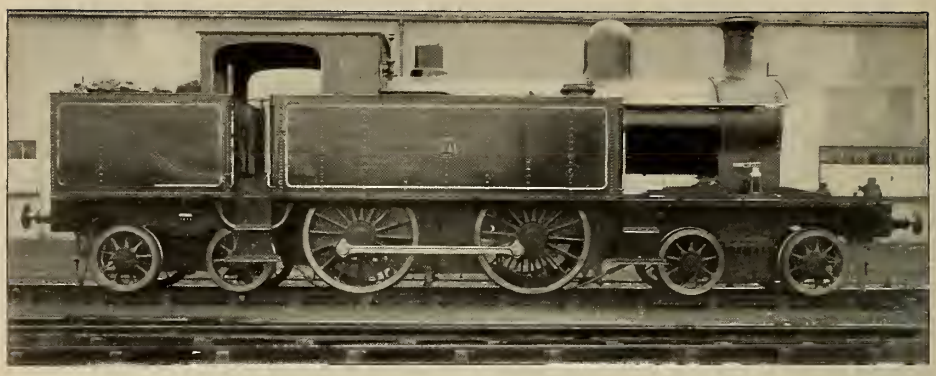
The Great Eastern engines are of rather larger dimensions, as their work is heavier, the usual load being 15 coaches, averaging 250 tons. One of their runs is from London to Enfield, 10¾ miles in 40 minutes, with 16 stops of a minute each. From this it will be seen that they are very efficient in starting away, and this is especially needful on this road as the stations in some cases are hardly over ½ mile apart, so that speed has to be attained in a minimum of time. This class of engine, with slight alterations, is used for local goods traffic also.

The engine of the Taff Vale Railway, shown on this page, is a representative of what can, in truth, be called the "mixed traffic" type, for as a class they are generally useful, either passenger or goods trains being worked with equal facility. The engine illustrated weighs 61 tons 10 cwts. loaded, of which upwards of 48 tons are available for adhesion. The wheels are rather large for the type, measuring 5 feet 3 inches. The cylinders are 17½ by 26 inches.

One of the most usual forms of tank engines employed in goods traffic is the six coupled saddle-tank locomotive. The wheels, as a rule, are of small diameter, about 4 feet being common. For short distances with long trains and for heavy shunting they are excellent. The Caledonian Railway locomotive has cylinders 18 inches by 26 inches, the diameter of the wheels being 4 feet 6 inches; 1000 gallons of water are carried in the saddle tank over the boiler.

For general shunting and work in docks and similar places the four-wheeled saddle tank is general. The wheel base of these engines is very short, so that sharp curves can be rounded with ease; the wheels are small and the cylinders of considerable size, so that a powerful engine is obtained in a small space. The cylinders are usually placed outside the frames, but inside cylinders are not uncommon.

A new type of tank engine has been introduced into Great Britain by the Wirral Railway Company, in the form



ONE OF THE WIRRAL RAILWAY COMPANY'S LOCOMOTIVES.

of a double bogie twelve-wheeler. The leading and trailing ends in this engine are both carried by a bogie, so that running one way is as free as another. The illustration above represents this type, which has since been introduced on the Midland and South Western Joint Railway with almost identical dimensions.

Current Topics.

Double stacks for locomotives have latterly again become prominent. Both in Great Britain and in the United States experiments have been made with them for the past year or two,—on the London and North Western Railway, under the supervision of Mr. F. W. Webb, the well-known chief mechanical superintendent of that line, and on the Toledo, Peoria and Western, and the St. Louis, Chicago and St. Paul railways,—and the results, generally, appear to have been favourable to their use. On the London and North Western road the stack, in outward appearance, looks like an ordinary one, flattened at the sides, the longer axis running in the direction of the length of the boiler; but there are two openings for the exhaust, one for each opening in the stack. The smoke box is divided into two separate chambers by a hori-

zontal plate, and one of the stacks passes down through this partition into the bottom chamber so as to bring its influence to bear on the lower tubes, while the exhaust through the other stack is intended to produce a pull through the upper tubes. In the American engines there is no partition in the smoke box, and the stack is placed with its longer axis running cross-wise of the boiler, the special object aimed at in this case being an equal distribution of draft between the centre and the outer flues instead of between the top and bottom ones. Judged offhand alone, both devices commend themselves favourably, the British one, perhaps, more so than the American one because of its partition feature, which would seem to insure greater certainty of the equalisation desired, and the test figures thus far available show a very acceptable percentage of coal saving over the usual single-stack arrangement. It is not unlikely, therefore, that more will be seen and heard of the new practice.

One of the most interesting legal decisions that has latterly been made in the United States is that arrived at not long ago by the Supreme Court of Indiana, and which was unanimous that the plea for an injunction restraining the oil companies from wasting natural gas should be granted. The suit was brought by the Attorney-General of Indiana to punish those who were violating the laws of that State forbidding the waste of natural gas. A local court had previously decided that this waste was legal on the ground that a man had a right to do what he chose with his own, but the Supreme Court reversed this decision and declared such waste illegal on the ground of the general public good. The court's decision is very popular in Indiana, as by stopping the waste of natural gas it is believed that the supply will be prolonged indefinitely and the industrial interests of the State will be served a most excellent turn. Certainly no one who is not familiar, through personal observation, with what has, for a long time, been going on in some of the natural gas districts of the United States, can have any conception of the reckless waste of the gas that has been, and is probably still being, practised. Not only have grossly inefficient forms of burners been used, but in many places there have been no burners at all and the gas has been burned simply from open ends of pipes, with no attempt at an admixture for proper combustion. Gas jets and fires, moreover, have been left burning at all times, day and night, simply to save matches and to avoid the trouble of relighting. Early exhaustion of the gas wells was to be expected under such conditions. Many of them have, in fact, given signs of distress, and the action that was taken in Indiana seems to have come almost in the nick of time.

Apropos of the article on nickel-steel armour which is published in this issue, it is worth noting that the uses of nickel-steel are not by any means confined to armour-plate making, but have extended in many directions, not the least important of which has been that into the railway field. Street-car axles, for example, are now being made at the famous Krupp works in Germany, with from 7 to 8 per cent. of nickel in their composition, and hollow driving axles for locomotives are similarly turned out. Fire-box steel, too, in many instances has a nickel admixture, and now the making of staybolts for locomotive boilers promises to afford a further outlet for the new steel. Staybolts are things which cannot be too good, and at least one railroad is accordingly making experiments now to determine how nearly nickel steel will fulfill the requirements of an ideal staybolt material.

Automatic stokers have become so intimately associated, in the minds of most engineers, with boiler firing alone, that their application to heating furnaces generally is apt to be looked

THE LARGEST MANILLA CABLE IN THE WORLD.

upon as something unusual. In at least one instance, however, at the works of a spring and axle company, automatic stokers, made by the American Stoker Company, of Brooklyn, N. Y., are thus used, the furnaces to which they are fitted being employed in heating springs and axles preparatory to bending and forging. Formerly at these works oil-fired furnaces were used, ostensibly to produce a steady and uniform volume of heat, but now slack coal is burned, available at lower cost, and, through the agency of the stokers, has been found to satisfactorily answer all the requirements.

WHEN the large floating dock for Havana, which was built at Wallsend, England, by Messrs. Swan & Hunter, Limited, for the Spanish government, was to be towed across the Atlantic last year, it was evident that something special was required in the way of towing appliances, and one of these was the manilla cable turned out by the rope works of Messrs. R. Hood Haggie & Son, of Newcastle-on-Tyne. One morning the inhabitants of the Wallsend district were interested in seeing a procession of seven horses, yoked to a heavy waggon, loaded with the huge rope, and the snap shot of the photographer has been faithfully reproduced on this page. The cable was the largest ever made, measuring 22 inches in circumference. Its length was 240 yards, its weight nearly 5 tons, and its breaking strain 180 tons, and it took 70 men to haul it up and coil it on to the heavy pulley.

THE question of the increasing weight and cost of passenger cars on railroads as compared with the number of passengers which these cars carry, was carefully gone over a short time ago by Mr. George J. Charlton, the assistant general passenger agent of the Chicago and Alton Railroad, in an interesting interview in one of the Chicago newspapers. According to Mr. Charlton's calculations, each passenger on an American railroad nowadays requires a dead weight of 2000 pounds for his accommodation, whereas twenty-five years ago each passenger was provided with a dead weight of only 1000. These figures, too, are true only when the car

has every seat occupied; when the car is only partially filled, the ratio of dead to live weight is proportionately increased. In other words, while the weight of a standard passenger car, seating 60 persons, was abont 50,000 pounds some years ago, the standard car of to-day, seating only 40 persons, weighs from 60,000 to 80,000 pounds. Mr. Charlton gives in detail the various items which have led not only to this increase in weight, but also to greater first cost—the heavier frames, the vestibules, the better lavatory accommodation, the hot water heating, the improved seats, and other features. He finally puts down the cost of an old style car at $4000, and of a new style car at $7000, and predicts that if the next twenty-five years shall see a continuation of improvements in passenger cars while rates continue to fall proportionately as much as they have during the last quarter of a century, the end of many of the great railways from such causes must be insolvency.

It is hardly within Mr. Charlton's scope to deal with the even more serious question of Pullman and Wagner sleeping cars, though he pauses to say that the cost of a modern American sleeping car is from $20,000 to $25,000. What is of more consequence from an engineering point of view is that the weight of an average sleeping car may be put down at 90,000 pounds and its possible number of passengers at 24. This would make the dead weight of a sleeping car equal to 3750 pounds for each passenger carried, even if every upper berth were filled, which very seldom happens. Thus, a train of 250 net tons, or 500,000 pounds, neglecting the weight of the engine, tender and baggage car, would afford accommodation for only 133 sleeping car passengers, or 250 ordinary car passengers, whereas with the day cars of 25 years ago 500 passengers could have been carried with the same weight of train. All this increase in the proportion of dead to live weight in passenger traffic must cut deeply into the net revenues of the railways from this class of earnings, for not only are heavier engines, rails and bridges required to haul and sustain the modern day and sleeping cars, but the ornately furnished cars require much larger sums than the older cars to keep them in repair. Mr. Charlton says, for example, that a prominent car builder told him that an average of $500 a car was expended on each car after it had been out for the first six months, merely for a "dressing down," as it is called, and that if anything in the nature of a "general repair" was attempted, a second $500 was necessary.

There can be no doubt that the insensate competition between the various railway companies is the chief cause of the increase of dead load in passenger trains from half a ton to a ton for each seat in the car. Does one company put on a new "limited" train, at a minimum cost of $125,000, with guaranteed hardwood cabinet finish, real velvet plush for seat covers and five frame Brussels carpet on the floors, then a rival company advertises a "limited" train equally as choice in its appointments, with the addition of a barber-shop, a bath-room and a typewriter. Yet there is in reality little demand for any of these luxuries by the pubic, the sensible portion of which would willingly exchange them all for the one vital necessary of good ventilation, the scarcest commodity in American railway travelling. The mere mention of plush, whether a material for seat covers or as curtains in sleeping cars, makes all devout sanitarians shiver; no more perfect trap for disease germs was ever devised. The time is sure to come when a new railroad genius will arise and make an end of the game of brag between American general passenger agents. This reformer will probably substitute light and easily cleaned bamboo seats for those now in use; he will probably save a good deal of the money now spent in useless ornamentation and spend it on better ventilation and lighting; and he is

likely to design frames and trucks much lighter, and at least as strong and durable, as those which carry the average day car of the present time. It is possible, too, that he may accomplish a good result by lowering the centre of gravity of the prevailing type of passenger car, thus preventing it from rolling at high rates of speed and obviating the supposed necessity of placing two or three tons of old rails in the floor to keep it steady. As for the sleeping car, it must be designed *de novo*. Given the interior of a car, with a certain number of cubic feet of space, the problem will be to apportion it so that each passenger may have the greatest possible amount of privacy, comfort and ventilation. Perhaps a beginning in this direction might be made by first equipping sleeping cars which are confined to making regular night journeys between fixed points, as, for example, New York and Buffalo or New York and Pittsburg, and *vice versa*.

FROM a lecture delivered before the Society of Arts in London, in 1890, by the late Sir George Findlay, General Manager of the London and North Western Railway, it is possible to abstract some figures bearing upon the weight of British passenger coaches and their proportion of dead to live load. In 1872 the standard third-class coach of the London and North Western Railway,—not a very comfortable affair,—weighed 22,400 pounds and seated fifty passengers. This gave a proportion of 448 pounds of dead weight for each passenger. In 1890, the vastly superior third-class standard coach of the same railway weighed 40,320 pounds and had good cushioned seats and backs for seventy passengers,—giving a ratio of 576 pounds dead weight for each traveller. This latter coach may fairly be compared with the American day car of 25 years ago, in which, it will be remembered, 1000 pounds dead weight were required for each passenger. Quite in line with the best American day car at present in service is the composite first, second and third-class London and North Western coach, with ample lavatory accommodation and a compartment for baggage. This car weighs 19½ long tons, or 43,680 pounds, costs £860, and has seating accommodation for thirty-three persons; but even here the proportion of dead to live load is only about two-thirds that of the American car with which it is contrasted, the ratio being 1323 pounds of dead load per passenger in the English example and 2000 pounds per passenger in the American one. The contrast is hardly so striking when the typical sleeping cars of the two countries are compared; but it must be borne in mind that the British sleeping car is more nearly akin to the American state room car than to the ordinary section car. Thus a London and North Western sleeping car weighs 22½ long tons, or 50,400 pounds, and gives accommodation to sixteen passengers. This is at the rate of 3150 pounds of dead load for each passenger, while, as already mentioned, the American section car has 3750 pounds of dead load for each passenger. For some reason or other the cost of a London and North Western sleeping car is only about one-third that of a Pullman or Wagner, being £1300, or $6500, in the one case, as against $20,000, or £4000, in the other. In the long run either American travellers must pay this difference in cost or the railway companies must be out of pocket by it; as it is, no one seems to profit by the over-elaboration of sleeping cars in the United States but the palace car builders.

A NOTICEABLE feature in recent ship construction is the value assigned to deck erections as elements of structural strength. There was a time, so the *Engineer*, of London, recently said, when, if a long bridge were built upon an upper deck, the vessel was penalised by having her sheerstrake doubled. Nowadays the fitting of a long bridge is insisted upon in vessels of large size and extra proportions, because of the strength which such an erection contributes when properly constructed. In

cases, too, wherein the building of a bridge house is not insisted upon, instead of penalising the vessel by doubling the sheerstrake throughout, the doubling is required at the bridge ends only, and material which would otherwise be put into the sheerstrake in way of the bridge house is advantageously transferred to the bridge house plating. It is, in fact, generally recognised that a long deck erection in the midship half length of the vessel should properly be a source of strength rather than the contrary. To make it such, however, it must be treated as an integral part of the structure and as the top of the girder. If not made strong enough to resist the stresses coming upon it, better by far to cut it asunder in sections, so that it may work rather than break. Long bridge houses in passenger liners now have continuous steel decks, additionally thickened side plating, and the landings of such plating double, instead of single, riveted either for the entire length of erection or certainly for some 20 feet or so at the ends, where the shearing stresses are greatest.

A FOUR-CYLINDER LOCOMOTIVE ON THE GLASGOW AND SOUTH WESTERN RAILWAY.

A FOUR-CYLINDER locomotive,—not compound,—was turned out early last year from the works at Kilmarnock of the Glasgow and South Western Railway, built after the design of Mr. James Manson, and for more than half a year past has been in regular service, working express trains between Carlisle and Glasgow, the distance between these two points being 115 miles. The four cylinders are placed side by side, all driving on to one axle, the two inside cylinders, 14½ × 26 inches, placed under the smoke box, having their connecting rods attached to the crank axle, while the two outside cylinders, 12½ × 24 inches, work upon crank pins on the driving wheels. The outside cranks are placed opposite the inside cranks, so that the reciprocating parts are balanced. The valves for the inside cylinders are placed between the cylinders, and are worked direct from the link motion, while the valves for the outside cylinders, which are on the top, are balanced,—that is, fitted with a relief ring or piston, and actuated by a rocking shaft. Only two sets of valve gear are required to work the four valves. The engine is a distinct locomotive novelty.

A COUPLE of centuries ago, in a carefully-prepared statement by the *Lancaster Herald* of the average estimated incomes of different classes of population from peers to crofters, there was included, according to Sir Benjamin

Baker, a class styled "followers of the liberal arts and sciences," which would doubtless comprise engineers. It is interesting to note that the average income per family of this group is given at £60 per year, as compared with £400 for eminent merchants, £154 for lawyers, £72 for eminent clergymen, £45 for shopkeepers and farmers, £38 for highly-skilled artisans, £15 for labourers, and £6 10s. for crofters or cottagers. As the family of a scientific gentleman in those days of universal marriage was estimated to average five in number, the expenditure per head must have been included within the sum of £12 annually; but fortunately, as the old chronicler quaintly remarks, families were smaller in London "from a greater intenseness on business, and from the unhealthfulness of the coal smoke." Engineers of those days were, therefore, probably after all somewhat better off than these figures indicate.

When one considers the convenience and efficiency of electro-magnets, it is a little curious that they should not have been used for lifting purposes to a greater extent than they have been. In the few places where their utility has been recognised electro-magnets have been made to fulfil most useful functions in transporting large masses of metal from one point to another. This has been the case notably at the Illinois Steel Works, at South Chicago, to which reference was recently made in these pages. Another remarkable instance of the use of magnetism in conjunction with lifting apparatus is at the Sandycroft Foundry, in Cheshire, England, where electro-magnetic cranes are in constant use for lifting pieces of iron and steel weighing as much as three tons. It has been found that the electro-magnets save considerable time and labour in the operation of unloading, loading, packing and removing pieces of metal. For lifting and packing billets of iron it has been found that three men can do the work in a quarter of an hour which previously took six men an hour and a half to perform. Moreover, the electro-magnets have been made so reliable that masses of metal can be moved with the greatest safety over the heads of workmen, though, as an extra precaution, chains are usually fixed on the material. Electricity for energising the magnets is obtained from the lighting circuits. For lifting weights of one ton the Sandycroft magnets weigh 250 pounds and take two ampères at 110 volts to energise them. There is nothing unusual in the magnets there employed; they are of the two-pole type, having specially shaped pole ends in order to present as great a surface as possible to different shaped material.

Electro-magnetic lifting devices have been in every-day use at the proof butts of the Royal Arsenal, at Woolwich, for over five years, and in the transport of heavy projectiles weighing as much as 1800 pounds. Formerly, to move a large number of shot was most laborious work, not only on account of the great weight, but by reason of the difficulty of getting slings around the projectiles. The introduction of the electro-magnet in place of the slings has rendered the task easy and one which is quickly performed. In this case the body or core of the magnet is of inverted U shape and in one forging, and the winding is mechanically protected by stout iron flanges and is covered by thick brass strips. The magnet is exceedingly efficient and requires about ⅛ horse-power to energise it for lifting a weight of 3600 pounds. The weight of the electro magnet complete is about forty-five pounds.

Some recently published German electric tramway statistics afford a good illustration of the rapid growth in electric traction that has taken place in Germany in the last half-dozen years, the figures having been brought down to September 1, 1897. At the close of 1891, it would appear from these data, only three towns had electric traction

in use, while in 1897 the number had grown to 56, and 34 additional cities had definitely decided to adopt electricity for tramway service. Of these 34 it was expected that eight would be in operation before the end of 1897, so that the total number of cities using electric traction at the beginning of the present year was 64. The existing roads have more than 600 miles of track, of which about one-half is double, and, with the exception of 11 miles of underground road in Berlin, and less than 75 miles of storage-battery system, this is all overhead trolley.

USING the water delivered from a steam pumping station as power-water for lighting the station through the intermediary of a small water-wheel and dynamo is something which has been done for some time at the water-works of Springfield, O., and the success of that installation has led to the adoption of a similar, though larger, one at the Columbus water-works, in the same State. According to Mr. W. C. Powell, the engineer at the Springfield station, they were too far away from the city electric plant to receive light from that source, and they therefore bought a 40-light machine and connected it direct to a 12-inch impulse wheel, made by James Leffel & Co., of the same town. This wheel takes water from the main service pipe inside the station, and the discharge is piped to the pump well so as to avoid waste of water. Under the minimum water pressure of 70 pounds at the station, thirty 16-candle power lights can be operated, with a water expenditure of 90 gallons a minute or 54,000 gallons for a ten-hours' run.

E. GYBBON SPILSBURY.

A BIOGRAPHICAL SKETCH.

EDMUND GYBBON SPILSBURY was born in London, sent at an early age to Belgium, and educated at Liège, and afterwards at the University of Louvain. At seventeen, in 1862, he became an assistant engineer of the Eschweiler Company of Stolberg, one of the largest miners and smelters of lead and zinc ores in the world, and after a year or two spent in mine-surveying, and the designing and erection of machinery, he was sent to examine and develop important zinc-discoveries in Sardinia, and thence, for a similar purpose, to the Atlas mountains, in Morocco. In 1865 he entered a London engineering firm, and subsequently managed for another London firm water-works interests in Leipzig and Vienna.

In 1867 he became designing engineer for a leading bridge-building firm in Westphalia, but was persuaded, soon after, to return to mine-engineering, as engineer of the Austro-Belgium Metallurgical Company. This company had been involved for ten years in an important lawsuit with a rival company, concerning mines and ores in the Bensberg district, where Mr. Spilsbury had been formerly employed by the Eschweiler Company. The technical management of the case was intrusted to him, and in one year he brought it to a conclusion highly satisfactory to his company, — certainly a remarkable achievement for a youth of twenty-three.

He then took charge, for a year or two, of new works under construction by the Austro-Belgian Company in Croatia, and, in 1870, was sent by that company to investigate the resources of the United States in lead and zinc. After spending nearly two years in this work, he resigned his position, in order

to devote himself to practice as a mining and mechanical engineer and metallurgist in the United States. He was the first to introduce there the Harz system of ore-dressing for the zinc-ores of Friedensville, Pa., and the calamines of Franklin, N. J. He was connected for many years with the famous litigation over the franklinite and zinc deposits of Sussex county, New Jersey, and the equally famous patent suits concerning the manufacture of zinc oxide. During the same period, he had a varied experience in explorations on the North shore of Lake Superior, and in Colorado, Montana, Utah and California.

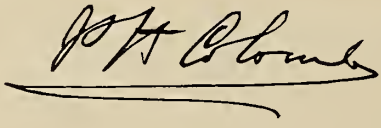
In 1874 he opened the zinc mines at Landisville, Pa., built concentrating and smelting works there, and managed the property until, in 1877, the exhaustion of the deposit caused its abandonment. He then became consulting engineer for the Coleraine Iron Company, and, in 1879, manager of the Lynchburg Iron Company, building at Lynchburg the first coke furnace in Virginia. In 1881 he became manager of the Haile gold mine, of South Carolina, and continued in this position, developing the property with highly creditable success, until 1888, when he became managing director of the Trenton Iron Company, at Trenton, N. J.,—a connection which he retained until 1897. During his management of these works, he introduced as specialties of their business the Elliot "locked" wire rope and the Bleichert system of aerial tramways. With the latter subject Mr. Spilsbury had been long identified, having made, in 1869, the acquaintance of C. Hodgson, the inventor of the Hodgson system of wire-rope transportation. In 1876 he built at Lewistown, Pa., the first long line in the United States (nearly two miles long), and a large number of lines now in operation were designed by him.

As early as 1864, Mr. Spilsbury contributed to the London *Mining Journal* articles on the concentration of ores, the mines of Sardinia, and other subjects, and his later contributions to technical literature, some of the most important of which are contained in the Transactions of the American Institute of Mining Engineers, have a high professional value.

As a vice-president of the institution just mentioned, he presided, in 1893, over the sessions of the mining division of the International Engineering Congress at Chicago, and in 1896 he was elected president of the institute.

R. W. RAYMOND.

PHOTO BY BARRAUDS, LTD., LONDON.



(See page 175.)

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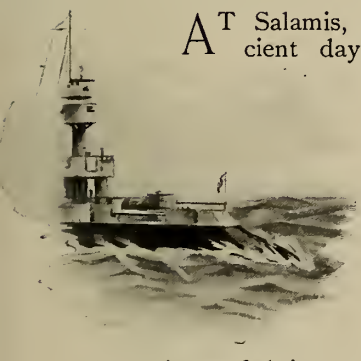
CASSIER'S MAGAZINE.

VOL. XIV. JUNE, 1898 No. 2

THE RAM IN MODERN WAR FLEETS.

By William Ledyard Cathcart.



AT Salamis, the ram of ancient days won victory for Greece. Through the stormy years of twenty centuries thereafter, it cleft the waves in many a bloody combat, until we see it at Lepanto but a fading factor in sea-fighting. In the time that followed, naval tactics were transformed. Sail freed the toiling oarsman; fleets moved to attack in close-hauled line ahead, not in the old line abreast; ships no longer charged each other, but, grappling, fought by twos and threes, broadside to broadside; and the crashing blow of the ram on waist or stem was succeeded by the cannonade at short range. So it was until steam appeared,—a power which gave again controllable propulsion and brought again the weapon of the triremes.

During the American Civil War the Confederate ironclad ram *Virginia*, known the world over as the *Merrimac*, and her last opponent, the turreted ironclad *Monitor*, made, in March, 1862, history, swift as momentous, not only for America, but for all naval nations. The hopeless, but heroic, conflict of wooden frigates with the ironclad and the later battle between the casemate and the turret, stirred the world and have left lasting traces on all naval construction since that time.

The United States frigate *Merrimac*, 4635 tons, 40 guns, was launched in 1855. In the spring of 1861, she was burned to the water's edge and sunk by the Federal forces at Norfolk, Va., U. S. A., on their abandonment of the dockyard there. Shortly thereafter she was raised by the Confederates and rebuilt as the mastless ironclad *Virginia*.

Her hull was cut down to the old berth deck and the ends were left just awash from bow and stern to the central casemate. The latter was 170 feet long, the full width of the ship, 7 feet high in the clear, with flat and open top, rounded ends, and sides inclined at an angle of 45 degrees. It was built of pine, 20 inches thick, with 4 inches of oak sheathing and two layers of iron plating, each 2 inches thick. Within it, there were mounted two 7-inch Brooke rifles on pivots, and, in broadside, six 9 inch Dahlgrens and two 32-pounder Brooke rifles. On her bow was fitted, for ramming, an iron spur which projected horizontally to a distance of 4 feet from the stem and at a level of about 2 feet below the water-line.

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DRAWN BY J. O. DAVIDSON.

THE FIGHT BETWEEN THE U. S. IRONCLAD "MONITOR" AND THE CONFEDERATE RAM "MERRIMAC," IN HAMPTON ROADS, VA., DURING THE AMERICAN CIVIL WAR, MARCH 9, 1862.

On March 8, 1862, a Federal fleet, powerful for those days, lay anchored in Hampton Roads, Va., from the inland entrance to which Norfolk was but nine miles away. It consisted of five steam and sailing vessels, carrying a total of 204 guns. Many rumours as to the new *Virginia* had reached these ships, but a bloody demonstration was needed to prove that she could resist their formidable batteries. About 1 P. M. a quartermaster reported:—

"I believe that thing is coming down at last, sir."

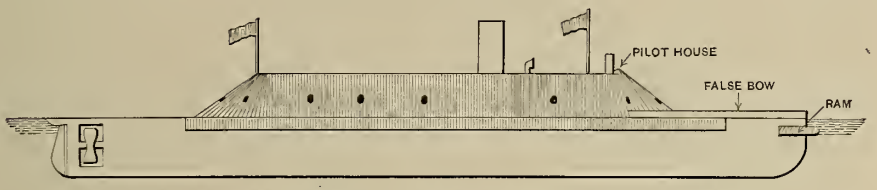
And soon, silent and grim, and attended by a squadron of small gunboats, the ironclad steamed from the river and moved sluggishly on toward the frigate *Congress*, 50 guns, and the sloop-of-war *Cumberland*, 24 guns, both sailing ships, which were anchored seven miles above the rest of the fleet. As the ram drew near, their batteries opened fire and the Northern navy learned its first lesson in modern war, when their shot rebounded like pebbles from her sloping sides, while her grape and shell wrought fearful havoc on their crowded decks.

Laying her course for the *Cumberland*, she received from her, through an open port, a hot fire, which "knocked off the muzzles of two guns and killed or wounded 19 men, but did not stop her progress." Forging slowly but steadily ahead, the *Merrimac* raked the helpless sloop, which, in vain, poured forth her fire, and then the iron spur struck her fairly beneath the starboard fore-channels. The *Cumberland* lurched heavily from the blow, which opened her side "wide enough to drive in a horse and cart." In a form, terrible as dramatic, the ram had reappeared in history.

Backing off and leaving his ill-attached spur embedded in the sloop's side, the Confederate commander demanded her surrender.

"Never! I'll sink alongside first!" Lieutenant Morris answered. His ship heeled to port and slowly settled, water pouring in at the bows; but, from her sinking guns, for more than half an hour, a fire—steady, but pathetic in its growing feebleness—was maintained, in answer to the enemy's butchering cannonade. Then, with a last shot from her half-submerged pivot guns, with her decks a shambles, and her torn ensign waving at the peak, she went down, bearing with her many dead and dying men.

Stirring as it is, there is not space to finish the story of that action. The *Virginia* had taught again the lesson of armour and the ram; but the failing fire of the stricken ship, in its unyielding valour, had answered again, for America, after unwarlike years, the question:—



SIDE ELEVATION OF THE AMERICAN CONFEDERATE IRONCLAD RAM "MERRIMAC."

"Mother earth, are the heroes dead?
Do they thrill the soul of the years no more?"

A fitting tribute is paid to Morris and his men in these words of an English author:—

"This great deed of arms, this unflinching refusal to yield to defeat, may well recall the fiction of the *Vengeur* and Du Chailla's great words:—'*Tirez, tirez toujours; c'est le dernier coup qui peut-être nous rendra victorieux.*'

"But the *Vengeur's* men had to fight ships of their own class and kind, and here the *Cumberland* was faced by an opponent whom she could scarcely hope to harm. It might have seemed wiser to surrender * * * and yet, it is well to remember that these lives were

THE SINKING OF THE ITALIAN "RE D'ITALIA" BY THE AUSTRIAN 'FERDINAND MAXIMILIAN" DURING THE BATTLE OF LISSA, IN THE ADRIATIC SEA, JULY 20, 1866.

not given in vain. * * * National character is a more sacred thing than even human life." [*Ironclads in Action.*]

That victory lies less in ships than in the men who handle them, is a historic truth which has had no stronger demonstration than that given by the battle fought off the island of Lissa, in the Adriatic, on July 20, 1866, between the Italian and Austrian forces.

Italy had, for that time, a noble fleet of ironclads and wooden ships; but, personnel to fight them; by concentration of fire, he hoped to offset superior armament; by chain cables, he armoured his wooden ships as best he could; and, as a last resort, he planned to sink his foe by ramming.

Although Tegetthoff had, more than once, invited battle, Persano's leadership had been marked, for weeks, by inaction and delay. This was due to no principle of Fabian strategy, but to the lack of preparation and of resolu-

THE "RE D'ITALIA" BEFORE THE BATTLE.

while her seamen were courageous, they were undisciplined and unskilled. As to their officers,—many were incapable and some were laggards in war. The commander-in-chief was Admiral Persano, whose performances in that battle seem like comedy on the high seas, with tragedy for epilogue.

Opposed to him was the Austrian admiral, Tegetthoff, a most able and energetic officer of long service. The ships of the latter were far inferior, both in type and number; but, by unceasing evolutions, he had secured a trained tion which ruled the Italian admiral to the disastrous end. Tegetthoff's probable arrival was known to him as he lay off Lissa, and yet, when the Austrian fleet was sighted, that of Italy was split into several groups, parted by miles of sea.

Signalling his scattered ships to rejoin, Persano first formed his available ironclads, after the ancient galley fashion, into "line abreast," which line did not, however, face the enemy's advance. Later, he changed its front, and, still later, reversed his tactics

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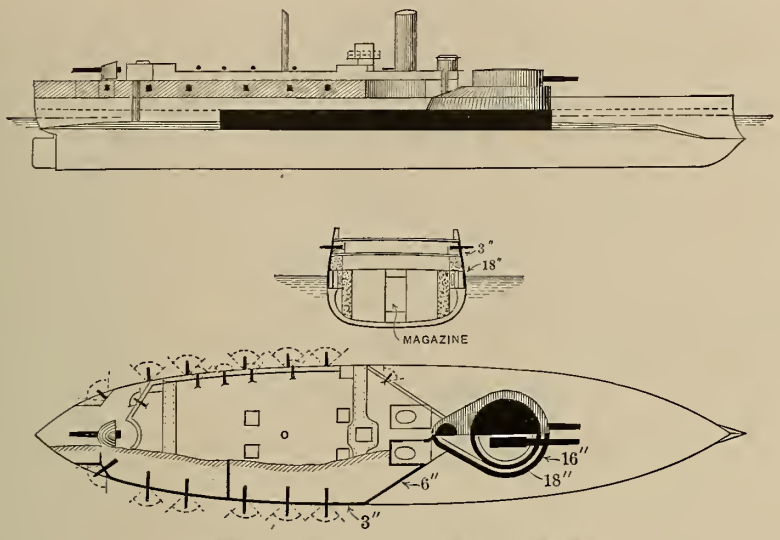
THE BRITISH BATTLESHIP "VICTORIA," SUNK OFF TRIPOLI IN THE MEDITERRANEAN BY COLLISION WITH H. M. BATTLESHIP "CAMPERDOWN" ON JUNE 22, 1893.

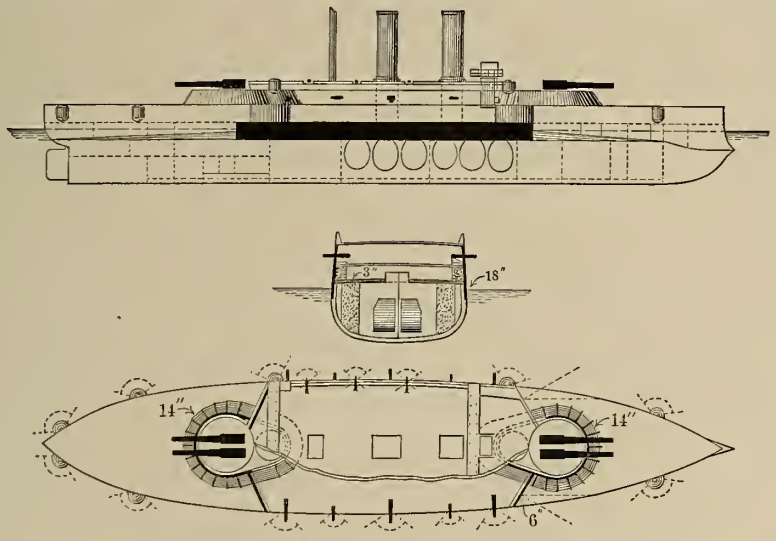
wholly and formed the "line ahead" of the old days of sail- an evolution



THE "VICTORIA." 10,500 TONS, 16½ KNOTS.

which, on the course steered, presented the broadsides of his ships to the enemy's ramming charge.

Again, just before the fleets met, he

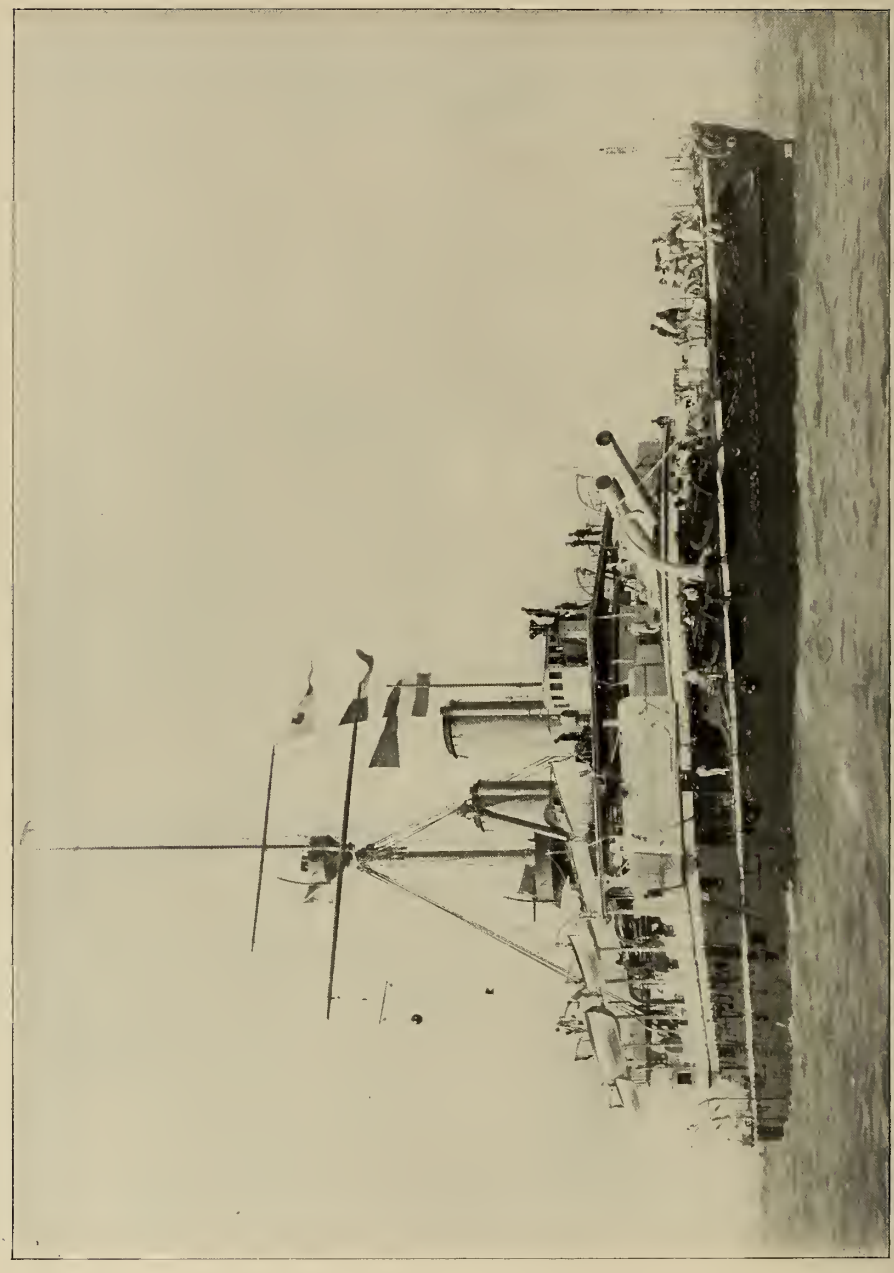


THE "CAMPERDOWN." 10,000 TONS, 16½ KNOTS.

stopped his flagship, the *Re d'Italia*— thereby throwing his column into confusion—and left her for another vessel outside his line. This move, made

without signal and without the previous knowledge of his captains, left his fleet practically without an admiral during the greater part of the *mêleé* which followed, since these officers, unaware of his absence, gave no attention—if, indeed, they saw them—to his signals from his new station.

At about half-past ten in the morning, Tegetthoff broke through the ill-



THE BRITISH BATTLESHIP "CAMPERDOWN."

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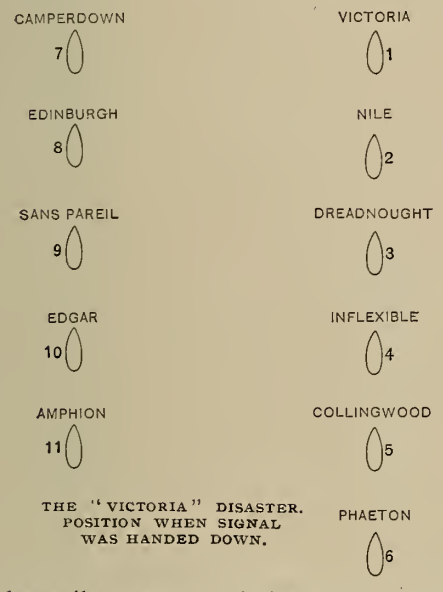
ormed line, his fleet being disposed in a strong, wedge-shaped formation, with the ironclads forming the point and sides. The Italian ships were painted gray; the Austrians, black. Tegetthoff's command was brief and to the point:—

"Ram everything gray."

With these orders, his fleet charged through and wheeled. And then began an action, or rather a series of smoke-beclouded combats, with the leaderless foe, which was waged hotly for more than four hours and which resulted in

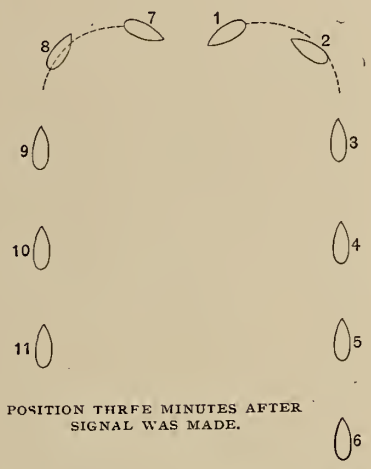


THE "VICTORIA" DISASTER. POSITION WHEN SIGNAL WAS HANDED DOWN.

the sullen retreat of the Italian fleet, with the loss of two ironclads.

The attacks by ramming were, perhaps, the most memorable of the many incidents of this fight. Indeed, it has been said that "Lissa was won by the ram." The *Re d'Italia*, Persano's deserted flagship, was sunk by this weapon, and with great loss of life. She had been the focus of attack by several Austrians and her rudder had been injured, although her engines were still effective. While thus crippled, she was rammed by Tegetthoff in his flagship, the *Ferdinand Maximilian*, which, at full speed, struck her, the ram cutting through her seven inches of armour without appreciable resistance and with no damage to itself, excepting to its paint.

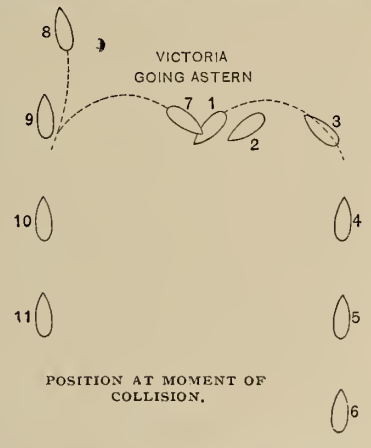
Heeling over to starboard and then rolling heavily to port, the great 6150-ton ship sank with a swiftness which chilled the blood of those who watched,



POSITION THREE MINUTES AFTER SIGNAL WAS MADE.

carrying many of her crew with her, but leaving a remnant to struggle in the sea. Long after, in recalling the sudden horror of all this, Tegetthoff said:—

"If I were to live a thousand years, I would never ram another ship. The effect produced is different from anything else you have in naval warfare. You see the vessel attacked at one moment, and, the next, 800 men sliding



POSITION AT MOMENT OF COLLISION.

into the sea with the vessel following them. You are left with a perfect void, without any commotion, without any smoke, without anything to make one feel that he was in battle."

DRAWN FROM SKETCHES MADE FOR THE LONDON GRAPHIC BY AN EYE-WITNESS.

THE "VICTORIA" SINKING AFTER BEING RAMMED BY THE "CAMPERDOWN."

In the notable record of more than half a century which Admiral Ammen, U. S. N., has presented in "The Old Navy and The New," he says:—

"Not long after the battle of Lissa, Admiral Tegetthoff, who commanded the Austrian force, gave me a graphic account of it. His flagship was very slow, but coming down with a fair wind increased her ordinary speed. In ramming the *Re d'Italia*, he actually ran through her. The most horrible sight that he ever saw, he said, was the severed parts sinking with hundreds of men struggling in the water."

Another ramming in this action, although unsuccessful, was still a dauntless deed. The Austrian *Kaiser*, a wooden line-of-battle ship, was surrounded by Italian ironclads. Turning her concentrated fire upon those abeam, she charged, in lumbering, but unswerving, fashion, the *Re di Portogallo*, a sister-ship of the *Italia*. While she drove in some of the enemy's armour-plate, it was with heavy damage and loss to herself. Receiving a broadside at close range, she was set on fire; and, when finally she backed clear and steamed away, the upper part of her stem remained in the *Portogallo*, her foremast and smoke-pipe had fallen, and her loss, in men, was large.

The Italian ships were, in number, nearly twice those of Austria, and, when it is noted that those of Tegetthoff were slower, that some of his ironclads were imperfectly armoured, and that his artillery could not penetrate the Italian plating, it will be seen how much, in material, he was outmatched. Italy's wooden ships, however, did practically no service, their commander, timorously and selfishly, holding them aloof during the conflict.

Dark as that day was for Italy, there was still proof that her seamen, despite incapable leadership, had retained the intrepidity which marked the sailors of Venice and Genoa in the golden age of their sea-power. The small armourclad *Palestro* retreated, in flames, from the action. Her officers and men refused to desert her; and, when the fire reached her ammunition, they went skyward with their shattered ship, and only 19, out of 230, survived the explosion.

To win Venice was Italy's purpose in this war; and, as the *Re d'Italia* sank, there rose from her doomed men, not a cry of fear, but a hoarse cheer, "Venezia!"—a heroic echo of that "song for Italy free" whose strains had stirred their sunlit land from the day, in 1831, when Mazzini pleaded with Charles Albert, King of Piedmont.

Men like these were worthy to win Venice; worthy of Carlo Zeno, the mediæval warrior of the still lagoon and of the open sea; worthy to follow the blind old doge, Dandolo, as he stood erect on the prow of his galley, in the summer sunlight at Constantinople, "with white locks flowing and sightless eyes aflame," a mark for every arrow of the foe.

On June 22, 1893, the British Mediterranean fleet was proceeding to an anchorage off Tripoli, Syria, the vessels being disposed in two parallel columns, with 1200 yards between. The starboard column was led by the commander-in-chief, Vice Admiral Sir George Tryon, R. N., in the single-turreted battleship *Victoria*, a vessel of the most modern type, carrying 659 officers and men. Directly opposite her, in the port column, was the battleship *Camperdown*, flying the flag of Rear Admiral Markham, R. N.

At 3.25 P. M. Tryon made signal for the columns to alter their courses 16 points (180 degrees), the starboard column to port and the port column to starboard. If this evolution could have been executed, the columns would have wheeled through a semi-circle inward toward each other and would then have proceeded — still parallel but much closer—in a direction the reverse of their original course.

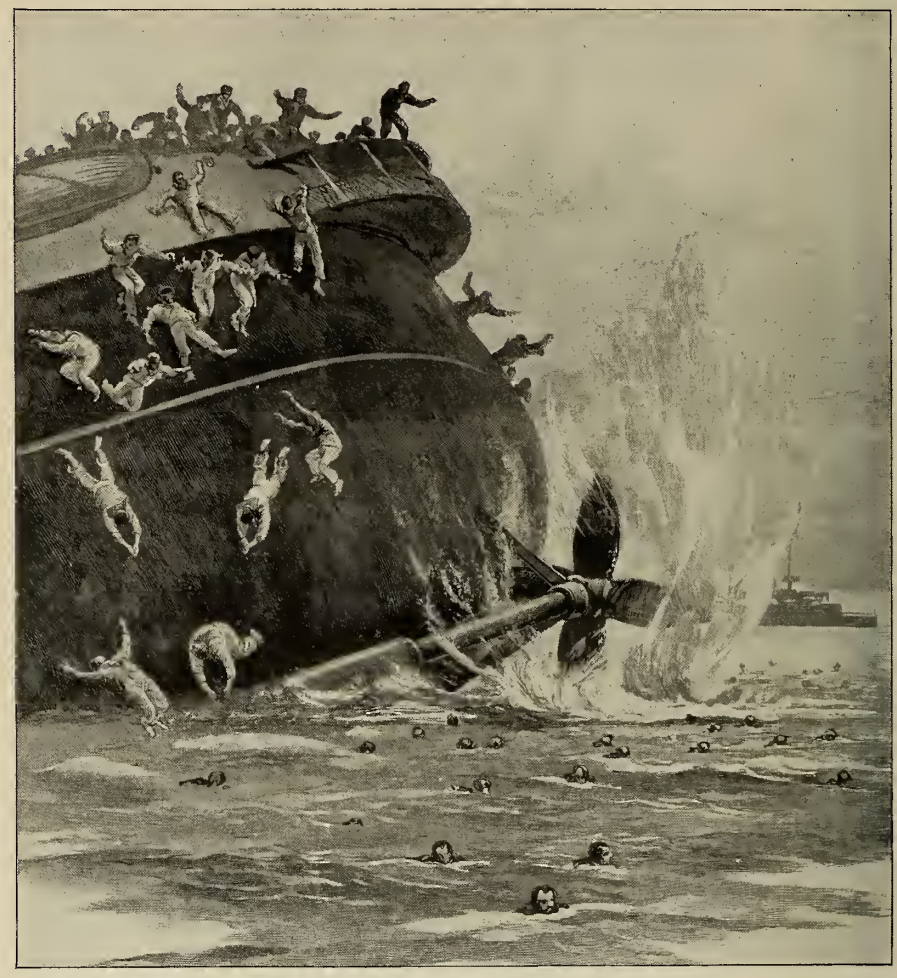
The 1200-yard interval, however, did not give space for such huge ships to turn. The manœuvre was impossible, and its grave danger was recognised, at once, by many; but discipline—without which navies cannot exist—forbade remonstrance or refusal, and so, as in Cardigan's charge, an evolution was

attempted which was known to be an appalling and most fatal blunder.

The ships had been steaming at nearly a 9-knot gait; and, when the turn was more than half complete, the *Camperdown*—despite engines reversed too late when even Tryon saw the danger—struck the *Victoria* on her starboard bow, nearly at right angles, at a speed of 6 knots, and with an energy of not less than 17,000 foot-tons. The blow moved bodily the bow of *Victoria* 60 feet to port and ploughed a rent 10 feet long in her upper deck, scattering splinters on all sides, while the actual penetration of the ram was not less than 6 feet.

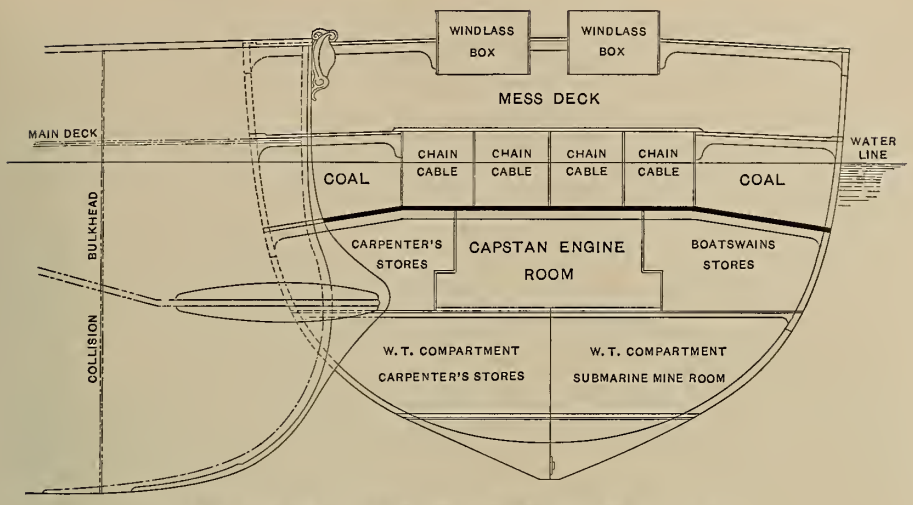
For about a minute, the two ships were locked, their sterns swinging toward each other and the rent growing. Then the *Camperdown*, with sorely injured stem, backed clear, leaving, in the *Victoria*, an opening, which, if unobstructed fully from within, would have allowed an initial inflow of 3000 tons of water per minute.

On the *Victoria*, there was coolness and discipline. For the moment, the



FROM SKETCHES MADE FOR THE LONDON GRAPHIC BY AN OFFICER WHO WITNESSED THE ECENE.

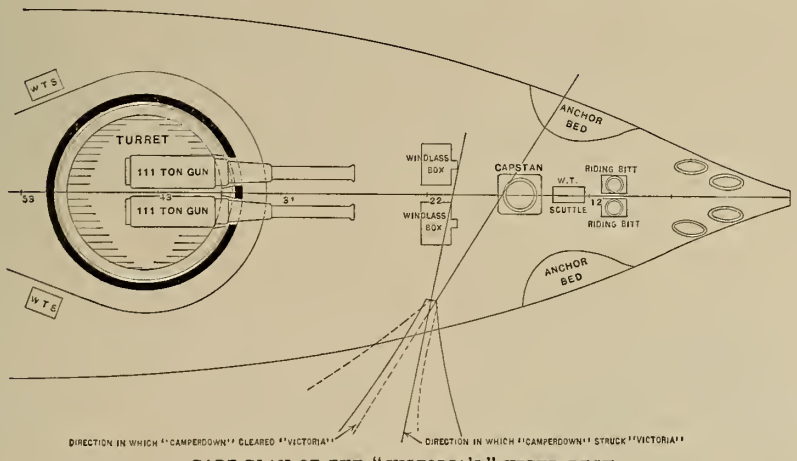
THE MEN JUMPING FROM THE "VICTORIA" AS SHE TURNED BOTTOM UPWARDS BEFORE GOING DOWN. THE TWIN SCREWS WERE WHIRLING RAPIDLY IN THE AIR, AND IN THE ABSENCE OF ANY RESISTANCE WERE GOING AT A TREMENDOUS RATE.



THE BOW OF THE "CAMPERDOWN" ENTERING THE "VICTORIA."

full danger was not realised. Orders to close compartment doors had been given and the captain went below to inspect them while Tryon remained on the chart-house, heading her for shoal water. For about ten minutes the crippled ship proceeded, settling gradually by the bow and heeling more and more

Before the lurch, her crew had been drawn up in ranks, four deep, on the port side of the upper deck, excepting the doomed men of the engineering staff, whose devotion to duty held them far below. While, then, all knew the ship was lost, there was perfect steadiness; with unfaltering discipline, they



PART PLAN OF THE "VICTORIA'S" UPPER DECK.

to starboard. Her after body lifted and the blades of the port screw showed. Then there came a sudden lurch, throwing, with a terrible crash, boats and heavy weights to leeward. She fell on her side, turned bottom upward, and sank, bow first, in 80 fathoms of water.

faced fate unappalled, as, in other days, British sailors had done on the *Birkenhead*.

With the lurch, came the order, "Jump!" and, climbing the sloping deck, they leaped for the sea—some to be butchered by the racing screws, some

THE LAST OF THE "VICTORIA."

to be killed or stunned by floating wreckage, some to be drawn down by the fierce suction, and others, within the hull, to meet for moments, happily but few, the awful torture of fire and steam in stokeholds and engine-rooms.

THE LATE ADMIRAL SIR GEORGE TRYON, WHO WENT DOWN WITH THE "VICTORIA."

Boats from the fleet saved many; but Tyron's error had cost, with his own, the lives of 321 officers and men.

The vice-admiral was, professionally, one of the most accomplished officers of the British service—a man of masterful temper, great ability, and wide experience in the handling of fleets. He had been ill; had, but that morning, returned to duty; and, in this, there seems to lie the cause of a blunder so palpable. A physical weakness which he would not recognise, had, for the time, dulled perceptions usually so acute. "It was all my fault," were his straightforward, if despairing, words.

The tragedy taught more than the power of the ram. It emphasised the value of practice in manœuvring fleets, since even trained minds may err and work such havoc. The importance of the human factor, the personal equation, was never, perhaps, more swiftly and terribly shown at sea. But, more than all else, the men of that hapless flagship proved, in the heroic splendour of their end, that they were fit successors of that host of stern sea-

men, who, in Great Britain's strife for ocean-empire, have fallen in battle, in storm, by tropic fever, or in northern cold—whose bones are "the drift of the deep sea floor" in every clime.

It was in West Indian waters that, in the old time, Admiral Hosier, cruising with seven ships of the line, buried three thousand of his plague-smitten men, "all in dreary hammocks shrouded," and himself died, broken-hearted. It is in the polar ice that there lies the unknown grave of that British sailor for whom two nations searched in vain and on whose empty tomb at home Tennyson's lines are cut:—

"Not here! the White North hath thy bones. And thou,
Heroic sailor soul, art speeding on thy happier voyage now
Toward no earthly pole."

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THE BRITISH IRONCLAD "WARRIOR," 1859.

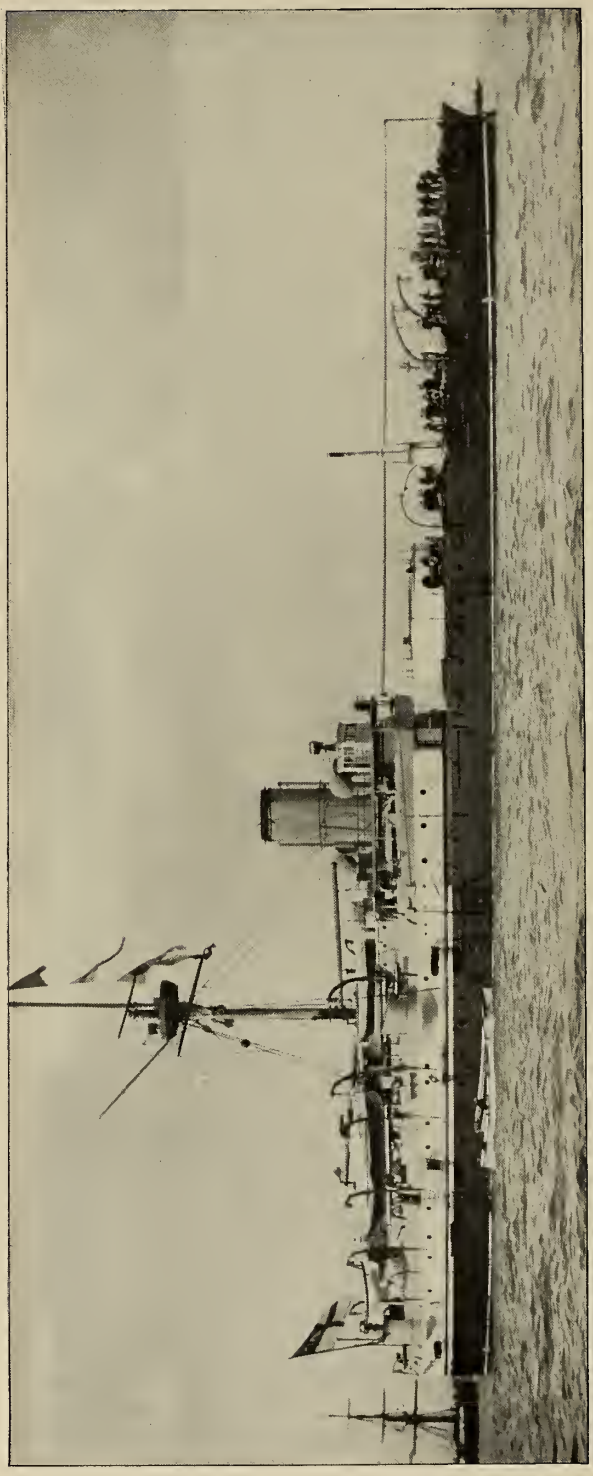
In the British Fleet.

In British battleship construction the ram has been recognised, practically from the beginning of the modern era, as an effective weapon of offence. Captain Eardley-Wilmot, R. N., writes:—

"From the *Warrior* (1859) to the latest phase of battleship, the ram has been continually developed in the bows of ships with a view to its use in future actions. In the *Warrior*, this was carried out in an imperfect manner; the stem formed an obtuse angle of large dimensions with the apex or spur, such as it was, at the water-line. When the power of the ram had been demonstrated in America, and afterward at Lissa, we frankly recognised that this weapon was of great importance. All the later vessels had bows which terminated under water in a sharp spur, forming a powerful ram, securely fastened to the ship, and weighing several tons."

In tracing the history of the ram as a primary weapon in certain ships of the British fleet, *Engineering*, of London, has said:—

"After the demonstration of the effective use of the ram in the American war and at Lissa, we, in common with some other nations, built light ships with powerful rams and with one, or at most a couple of guns, mounted in a forward turret. The old *Hotspur* and *Rupert* represent this stage in the evolution of the class. In the succeeding ships, the



THE BRITISH TURRET RAM "HERO."

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Hero and *Conqueror*, heavier guns with weapons for stern-fire were fitted with larger engine power. Later, as a result of the agitation headed by Admiral Sir George Sartorius, the *Polyphemus* was built, her only function being to ram, and thus her armament consisted of light guns to ward off torpedo attack." The *Rupert*, 3200 tons, and the *Hotspur*, 4010 tons, are small, coast-defense ironclads of the low freeboard type, carrying one or two heavy guns in a forward turret. Their principal reliance is on the ram, the bow armour being carried down, to reinforce it, below the point of the spur. The *Rupert* has been refitted recently and it is now a vessel of 6000 I. H. P., 14.4 knots, with two 9-inch and two 6-inch rifles, and ten rapid-fire guns.

The turret-ram *Conqueror* was launched in 1881; her sister-ship, the *Hero*, in 1885. They are vessels of 6200 tons, 5859 I. H. P., 15½ knots, and carry two 12-inch rifles in a single turret forward, and four 6-inch rifles, in broadside, on superstructure aft. They have low freeboard forward and their rams are reinforced as in the *Rupert*. Their main defect is that their guns cannot be fought in even a light sea.

As has been stated, the building of the *Polyphemus* was the result of the campaign, in behalf of the ram as a weapon

of primary importance, waged by Admiral Sartorius from 1855 onward. She is of 2640 tons' displacement, 5780 I. H. P., 17.8 knots. Her length between perpendicular is 240 feet; extreme beam, 40 feet; mean draught, 20.5 feet. Her offensive power lies in a strong ram and a torpedo equipment; she carries a few light guns for repelling torpedo craft.

Her hull is approximately cigar-shaped, with a light superstructure at the ends, and a flying deck in the middle, of its upper curved surface. The crown of the latter is 4 feet 6 inches above, and the curved contour ends 6 feet below, the water-level; beneath this, the section is *V*-shaped. The curve carries steel armour 2 inches on the crown and 3 inches on the sides. There are numerous water-tight compartments. The keel is hollow and holds 300 tons of cast iron ballast in sections, which may be detached, partially or wholly, to secure additional buoyancy. In addition to the main rudder, there is one on each side of the bow, capable of being raised, at will, into suitable recesses. The ram is a powerful spur, pierced for a torpedo-port and extending 12 feet beyond the stem at such a level that it will strike below the armour-belt. She is a remarkably handy vessel.

Commander Galwey, R. N., in 1885, summarised the advantages of the *Polyphemus* as follows:—

"First: that she has a very high speed, combined with fair manœuvring power. Second: that she can discharge her torpedoes with certainty, either ahead or on the beam, when proceeding at full speed. Third: that her crew and weapons of offence are protected by the most perfect armour possible, viz., 10 feet of water. Fourth: that she presents a mark of only four feet above the water-line." Modern experience with torpedoes renders the second of these claims somewhat doubtful.

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H. M. TURRET SHIP "HOTSPUR," GUARDED AGAINST TORPEDO ATTACK.

Excepting the *Polyphemus*, the vessels described, though relatively small, are essentially of the battleship class. As to the typical cruiser, it may be said,

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THE BRITISH TORPEDO RAM "POLYPHEMUS."

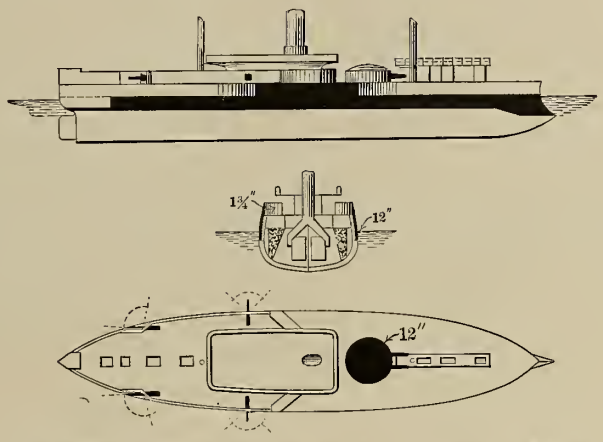
that, while its bow construction admits usually, in its contour, the possible necessity of ramming, it is structurally so weak as to make that mode of attack dangerous to the assailant as well as the assailed. Especial interest, therefore, attaches to the four new "fleet-cruisers" of the *Furious* class, which may be considered, in a measure, as the lineal successors of the *Rupert*, *Conqueror*, and *Polyphemus*.

These vessels—the *Furious*, *Gladiator*, *Vindictive*, and *Arrogant*—are of 5700 tons displacement, mean draught, 21 feet, 320 feet length, 57 feet 6 inches beam, and 19 knots speed. They have an armoured deck, fore and aft, covering the machinery, and a partial water-line belt of 2½ inches nickel steel plating. The ram-bow is massive; the stem is well braced, the framing heavy, and the shell-plating 1 inch thick, while over the latter there is the armour-belt, which, at the stem, is the full depth of the ship, but decreases gradually in width along the water-line until it terminates at 50 feet from the bow.

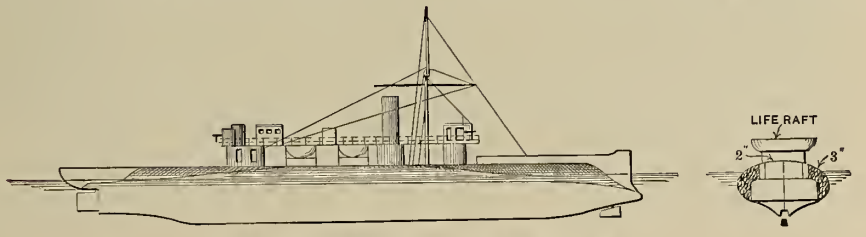
Manœuvring power, a most important quality in a prospective rammer, has been especially considered, both in dimensions and steering appliances. According to *Engineering*, "they are the shortest cruisers for their size in what may be termed the modern navy." There are two rudders, both astern, one

forward, the other aft, of the screws, the former being smaller and auxiliary. Aft, at the "deadwood," the bottom slopes upward, giving the screws solid water in which to work.

They carry, each, four 6-inch and six 4.7-inch rapid-fire guns, twelve smaller pieces of this type, and two 12-pounders. Despite their especial fitness for ramming, these vessels lack nothing in armament, when compared with the ordinary cruisers of their size; although, in the ram proper, ordnance has been hitherto a minor, and, to some authorities, an objectionable, consideration.



THE BRITISH TURRET RAM "CONQUEROR. 6200 TONS, 15½ KNOTS.



THE "POLYPHEMUS." 2640 TONS, 18 KNOTS.

The British fleet includes also original and improved forms of what were once known as "ram-cruisers"—the remarkable ships of the *Esmeralda* class. The name recalls a combat distinguished in naval history for the fierce ardour shown by the men of the beaten ship and their sustained courage against overwhelming odds.

Chili and Peru were at war and two small Chilian vessels were blockading the harbour of Iquique. One of these, the wooden corvette *Esmeralda*—850 tons, fourteen 40-pounder rifles—was decrepit and shaky, without speed, and armed with feeble muzzle-loaders; but, behind her ancient guns and in her engine-rooms, there were steadfast and unyielding men.

On May 21, 1877, she was attacked in the harbour by the Peruvian *Huascar*, a turreted ironclad of 1130 tons, greatly her superior in speed, with a bow reinforced for ramming, and carrying two 10-inch, two 40-pounder, and one 12-pounder muzzle-loading Armstrong guns. The Chilian lay close to the shore, and, from it, she was fired on by a field-battery at short range. Thus surrounded and out-matched, for four hours, with most stubborn gallantry, she fought.

Two boilers burst; her engine was wrecked; her engineer officers were killed. Twice she was rammed, and, each time, as the ships touched, a "forlorn hope" from her reached the ene-

THE PERUVIAN TURRET SHIP "HUASCAR."

my's decks to meet the death they sought. At last, as she settled slowly, with flooded magazine and silent guns, the *Huascar* struck her at full speed and the *Esmeralda* sank, her unconquered flag still flying as the sea closed over her.

Her name lives not only in Chilian history, but has an honoured place in that of naval architecture, for her successor, the second *Esmeralda*, was that most striking triumph of the Armstrong Company, of England, which has been the prototype of a full fleet of cruisers in the navies of the world. While these ships carry exceptional batteries and are not built primarily as rams, their speed —phenomenal for their displacement in their day—and their strong, spurred bows, caused them to be classed as "ram-cruisers."

The second *Esmeralda*, launched in 1884, is a vessel of 2920 tons, 6500 I. H. P., 270 feet length, 42 feet beam, 19 feet draught, and 18¼ knots trial speed A protective deck, 1½ inch thick, shielded her from end to end below the water-line and she carries a battery of two 10-inch, six 6-inch, two 6-pounder, four 3-pounder, and two machine-guns. She is now the *Idzumi*, of Japan, and the name is perpetuated in the Chilian Navy by the third *Esmeralda*, a vessel of 7000 tons, which was illustrated in the issue for July, 1897, of this magazine.

The United States cruiser *Charleston*, 3730 tons; the British *Mersey*, 3550 tons; the French *Sfax*, 4400 tons; the Japanese *Naniwa-Kan*, 3730 tons; with the Italian *Bausan* and her consorts, are all younger and improved sisters of the famous Chilian flyer.

The ram of the British *Mersey* was strengthened in what was then a novel way with a brace of 3-inch steel which extended horizontally through the spur and projected outside the skin on each side. Great Britain has developed the *Mersey* design in the *Orlando*, a belted cruiser of 5000 tons; and, in France, there has been built, as an improved *Sfax*, the *Cécile*, 5766 tons, with her later sister, the *Tage*, 7045 tons. It will be seen that the *Esmeralda* has left marked traces on the cruiser design of many navies.

While the British fleet has had, in

battle, no experience with the ram, there have been other ramming collisions than that of the *Victoria*. The most noted of these was that between the *Iron Duke* and *Vanguard*, the result of which was the loss of the latter vessel.

They were sister-ships of 5900 tons, formation being line ahead, with the *Iron Duke* in the rear and the *Vanguard* next in advance. There was a heavy fog, and, shortly after noon, the *Vanguard* sheered to starboard to avoid a sailing ship. This reduced her speed, and the *Iron Duke*, following closely,

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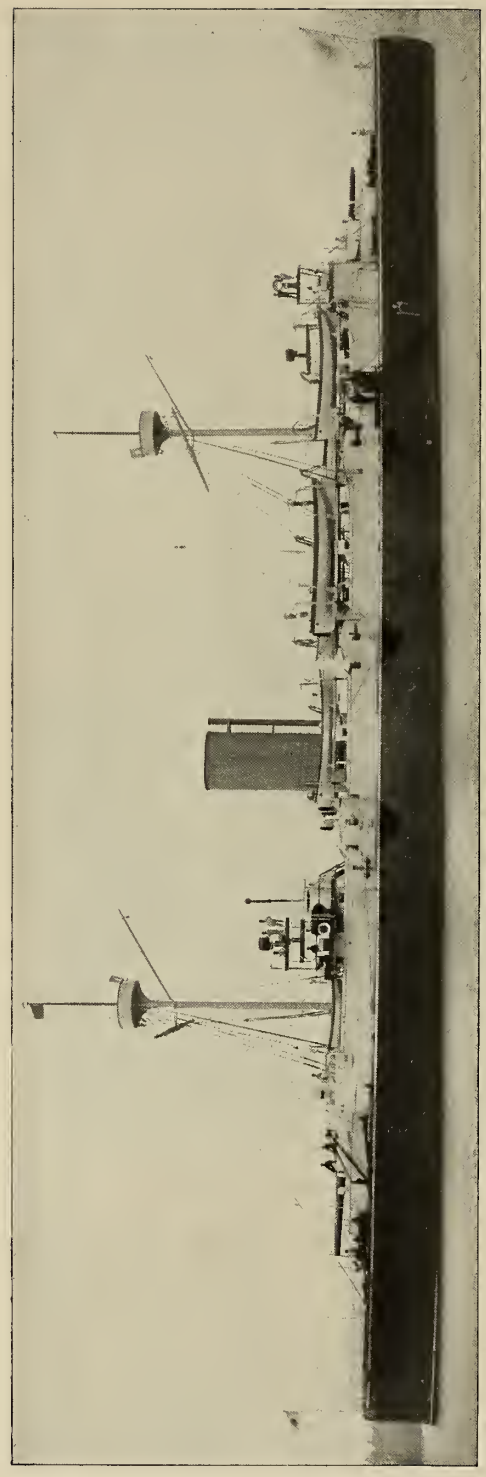
LAUNCHING H. M. S. "GLADIATOR."

3500 I. H. P., 14.9 knots, and carried, each, 450 men. They had a central battery with 6-inch armour, an armour-belt from 6 to 8 inches thick at the water-line, and mounted ten 12½-ton muzzle-loaders and two 64-pounders.

On September 1, 1875, they were steaming, with the *Warrior* and *Hector*, from Kingstown to Queenstown, the struck her on the port side, in a most fatal place, at the bulkhead separating the boiler and engine-rooms, thus destroying the integrity of two of her largest compartments.

Her armour was driven bodily inward more than a foot, while the bottom plating was torn open to the extent of about 25 square feet. Owing to the form of



THE JAPANESE CRUISER "NANIWA-KAN."

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the ram, its spur penetrated the *Vanguard's* side for only about 3½ feet, and did not pierce the inner skin. The inflow of water to the hold was therefore relatively slow,—from 15 to 27 tons per minute,—and the vessel floated for more than an hour.

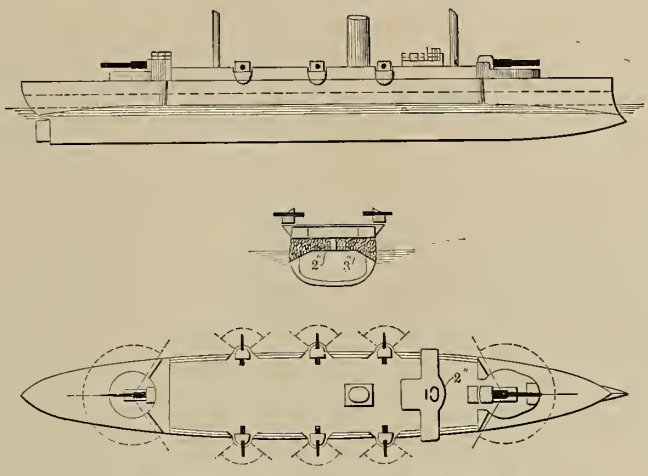
The boiler-room was quickly flooded and the ship left powerless. There was little confusion; the men were mustered, and the order, "Abandon ship!" was given. The *Iron Duke* steamed up as close as possible; and, within twenty minutes, the wrecked crew were safe on her decks. Sir William H. White, assistant controller and director of naval construction of the British Navy, says as to this collision:—

"Had the *Iron Duke's* bow been shaped like the *Camperdown's*, with the spur projecting 7 feet before the vertical portion of the stem, the spur would have pierced and seriously damaged the inner skin of the *Vanguard*, and that ship must have sunk with much greater rapidity," anticipating possibly the experience of the *Victoria*.

In the French, Italian, and German Fleets.

"*Toujours l'audace*" is the principle which seems to have guided the builders of the modern fleet of France. To a marked degree, they have been untrammeled by conservatism, and, with daring—wise, as a rule—they have led in much of the advance of the last forty years. France was the first country to float armoured batteries and the first to lay down armoured frigates, although with the *Erebas*, floating battery, and the frigates of the *Warrior* class, Great Britain was, in each case, a close second.

Over America, France's priority, in practical result, seems as clear. During the war of



THE "NANIWA-KAN." 3730 TONS, 18.8 KNOTS.

1812 John Stevens, seer as well as engineer, laid before the United States government plans for a battery protected by armour and moved by steam. When he had passed to his rest, his sons continued his labours, experimenting with projectiles against armour, and, in 1842, contracting with the government to build an armoured vessel of war; but though the work was continued until the beginning of the American Civil War, the ship was never finished and did not leave the ways.

So the United States lost, for the time, the fruit of the labour of a family as strong in its generous patriotism as it was brilliant and far-seeing in its en-

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THE BRITISH CRUISER "MERCURY."

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THE ITALIAN CRUISER "GIOVANNI BAUSAN."

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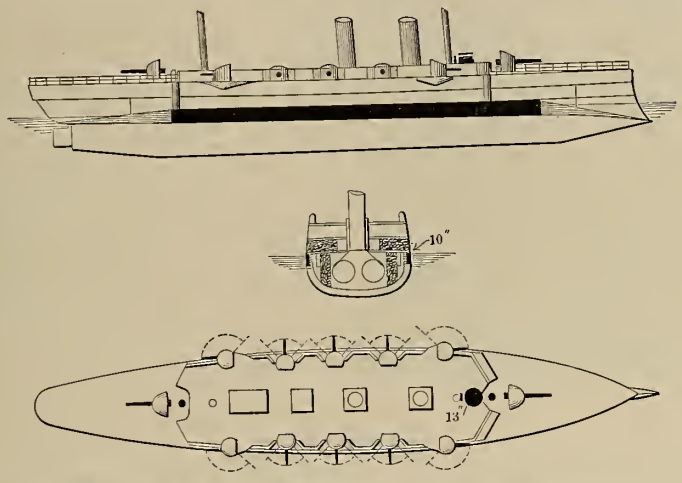
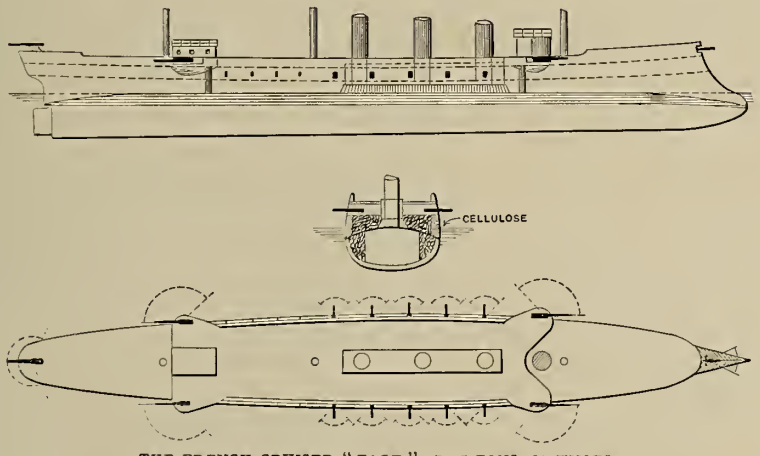
H. M. S. "IRON DUKE."

gineering skill. Europe reaped where America had sown. Half a century after John Stevens had wrought, with prophetic vision, for his country—when we find the United States warring with, and against, armour clads, we see, as well, that, in practical development, France has distanced it, in time at least; that "while the *Monitor* was hanging between life and death at the end of a tow-line on her first sea-passage, a French ironclad had, already, breasted the waves of mid-ocean alone, with her head to the westward; and while Americans in the North spoke with awe of the invulnerability of the *Monitor*, the guns of the *Normandie* rang out, in Vera Cruz, a challenge to the United States." (*Lieutenant Very, U. S. N.*)

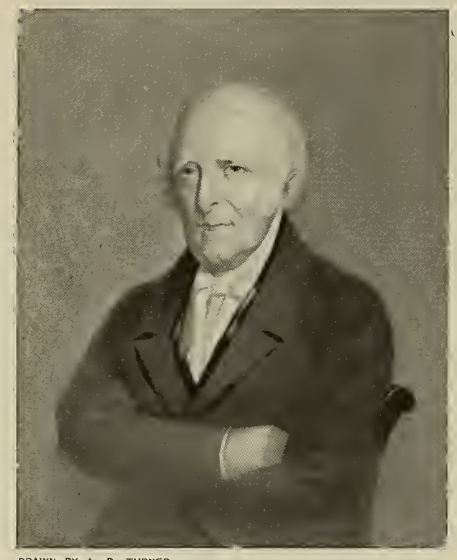
As with armour, so with the ram, In 1843, Lieutenant, afterwards Admiral, Labrousse, advocated its use as a weapon; and, in 1859, there was built into the French frigate *Magenta* a sharp spur,—the first modern ram. From that time onward, French constructors have rung the changes through every variation in its contour, from the great



THE BRITISH BELTED CRUISER "ORLANDO." 5000 TONS, 17½ KNOTS.



THE FRENCH CRUISER "TAGE." 7045 TONS, 19 KNOTS.



DRAWN BY A. D. TURNER.

JOHN STEVENS, 1812.

protruding prow of the *Dupuy de Lôme* and the rounded bow of the *Jemmapes* to the straight and ram-less stem of the *Brennus*.

During and after the Civil War in America, France constructed a number of ironclads for coast defence having a strong and prominent ram bow and a gun, or guns, in a single turret, for, in France, the ram, pure and simple, has not found favour, but is combined with heavy bow fire. The *Taureau* was built of wood in 1863. She was a ram mounting forward one 24-centimètre gun in barbette. Later, four vessels of her type were constructed, but carrying two guns of this calibre in a revolving turret forward.

In 1866 the ironclad ram *Dunderberg* was completed by private contract for the United States government; this vessel was subsequently sold to France and re-named *Rochambeau*. For her day, she seems to have been remarkable, not only for the great length of her ram, but in other features which seem to make her the forerunner in not a few important principles of modern battleship construtcion. Her principal data were:—Displacement, 6950 tons; I. H. P., 4500; speed, 15 knots; length, between perpendiculars, 358 feet; extreme, 377 feet; breadth, extreme, 72 feet 10 inches; draught, mean, 20 feet; battery, four 15-inch and twelve 11 inch guns. She was constructed by William H. Webb, of New York, the builder, also, of the *Re d' Italia*, before noted.

Italy, unmindful of Lissa, has put much of her modern tonnage into great, somewhat unwieldy ships. In the *Italia*, however, the ram-bow is of exceptional strength; "a heavy, central, longitudinal bulkhead, three longitudinals, the armoured deck, a horizontal bulkhead, and all the decks are strongly tied to the stem, which is a heavy piece of wrought iron, weighing 20 tons, projecting 6½ feet, at a depth of over 8 feet from load water mark. The outer skin of the bow is doubled and through-bolted to the stem."

This vessel is worthy of more than passing notice. She is a stupendous floating battery, which, in her day, challenged the admiration and the criticism of the naval world. Launched in 1880, she was followed by the *Lepanto*, of the same type; and the leading principle of her design, the omission of external armour, prevailed in the *Re Umberto*, the *Sardegna*, and the *Sicilia*, other huge vessels of the fleet.

The *Italia's* length is 407 feet; beam,

DRAWN BY A. D. TURNER.

ROBERT L. STEVENS.
THE DESIGNER OF THE STEVENS BATTERY.

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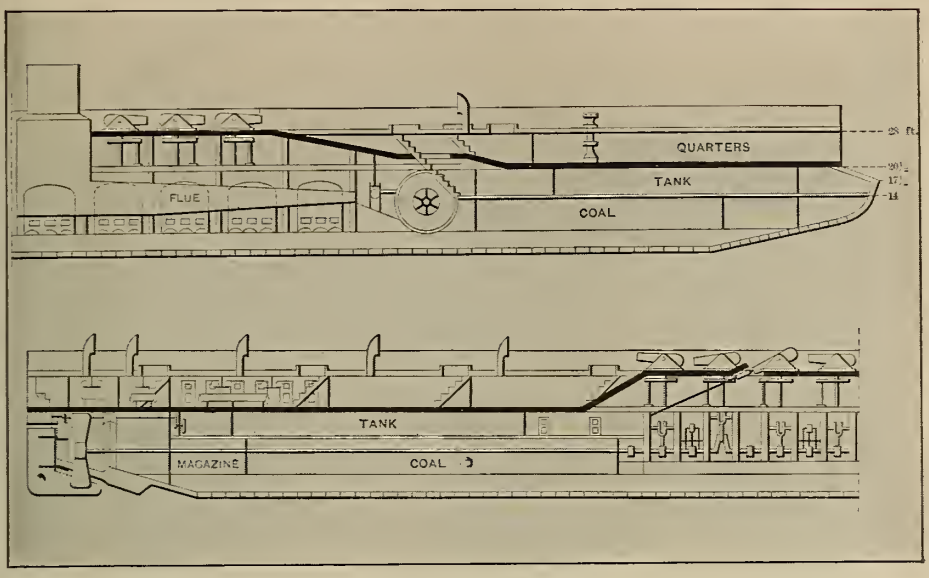
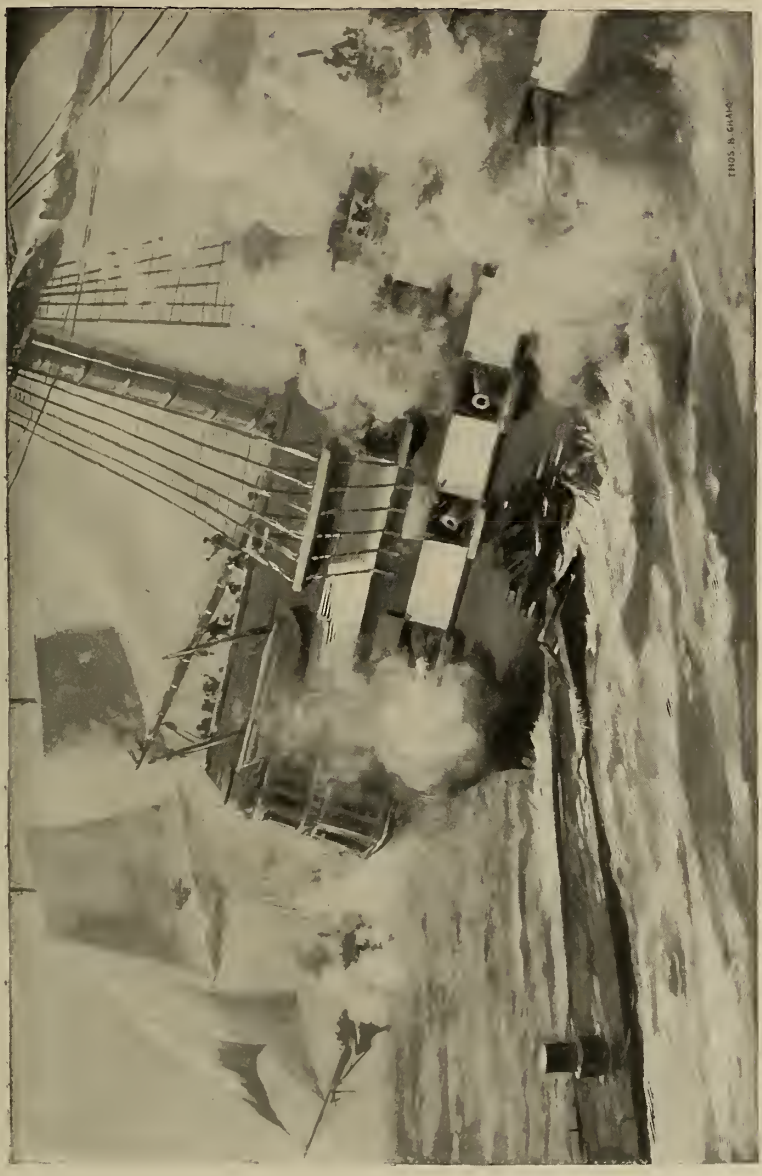


A LONGITUDINAL SECTION.

DRAWN BY THOS. E. CRAIG.

THE STEVEN BATTERY.

THE STEVENS BATTERY APPROACHING AN ENEMY'S FLEET.



THE ATTACK.

THE FRENCH TRIPLE-SCREW CRUISER, "DUPUY DE LÔME."

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MODEL OF THE RAM "DUNDERBERG."

73 5-6 feet; mean draught, 27 5-6 feet; displacement, 13,900 tons; I. H. P., 18,000; speed, 17.6 knots. Her armament consists of four 16.9-inch, 106-ton rifles, in pairs, in central armoured redoubt, and eighteen 6-inch, 4 ton rifles on spar deck, superstructure, and upper battery deck.

She has a protective deck, armoured, extending from end to end above her machinery; between this and the lower battery deck there is a cellular space—the "unarmoured raft" upon which the ship depends for protection to stability. Then follow the upper battery, or third, deck; and finally the fourth, or spar-deck, on which stands an oval redoubt, heavily armoured. This redoubt, with

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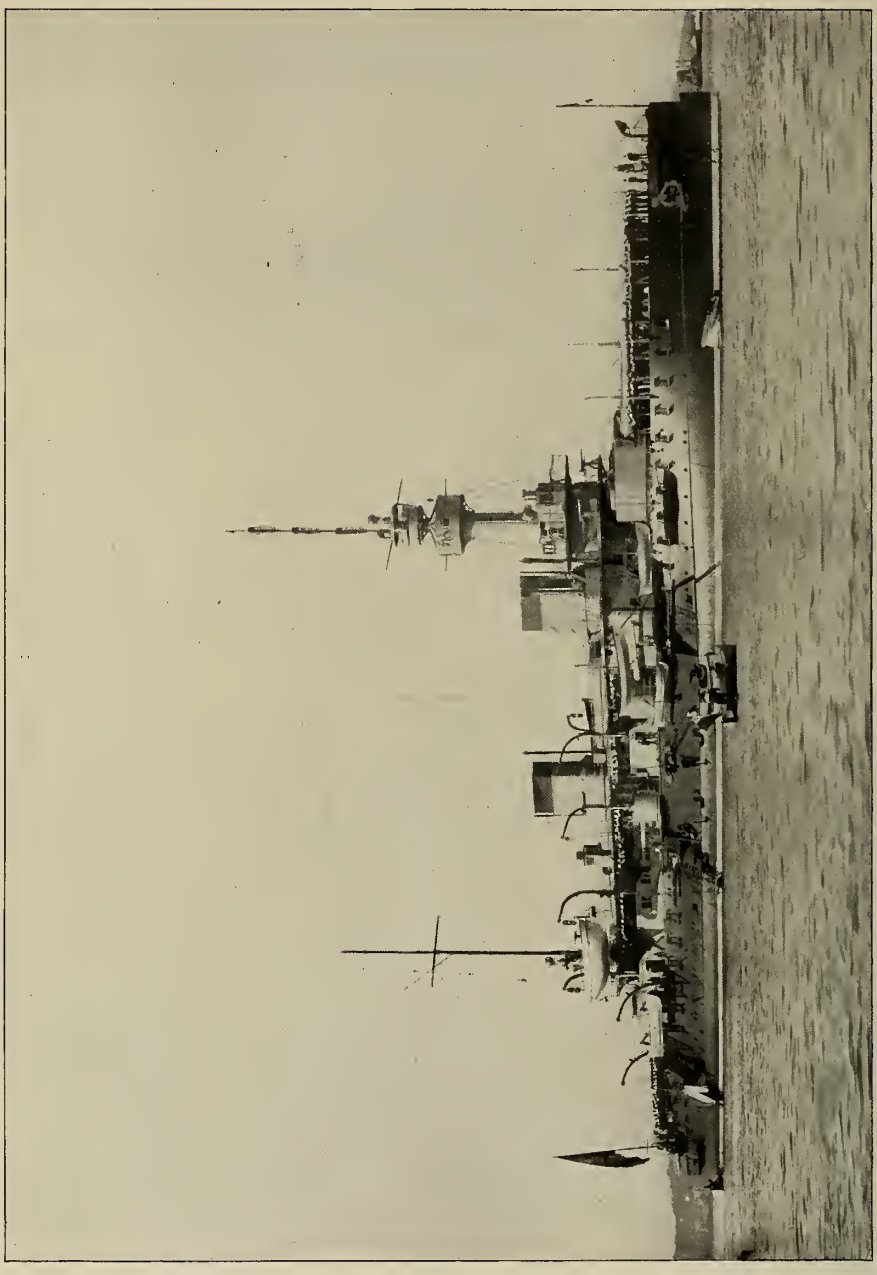
THE FRENCH TORPEDO GUNBOAT "CASABIANCA."



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THE FRENCH BATTLESHIP "BRENNUS"

THE FRENCH BATTLESHIP "JEMMAPES."

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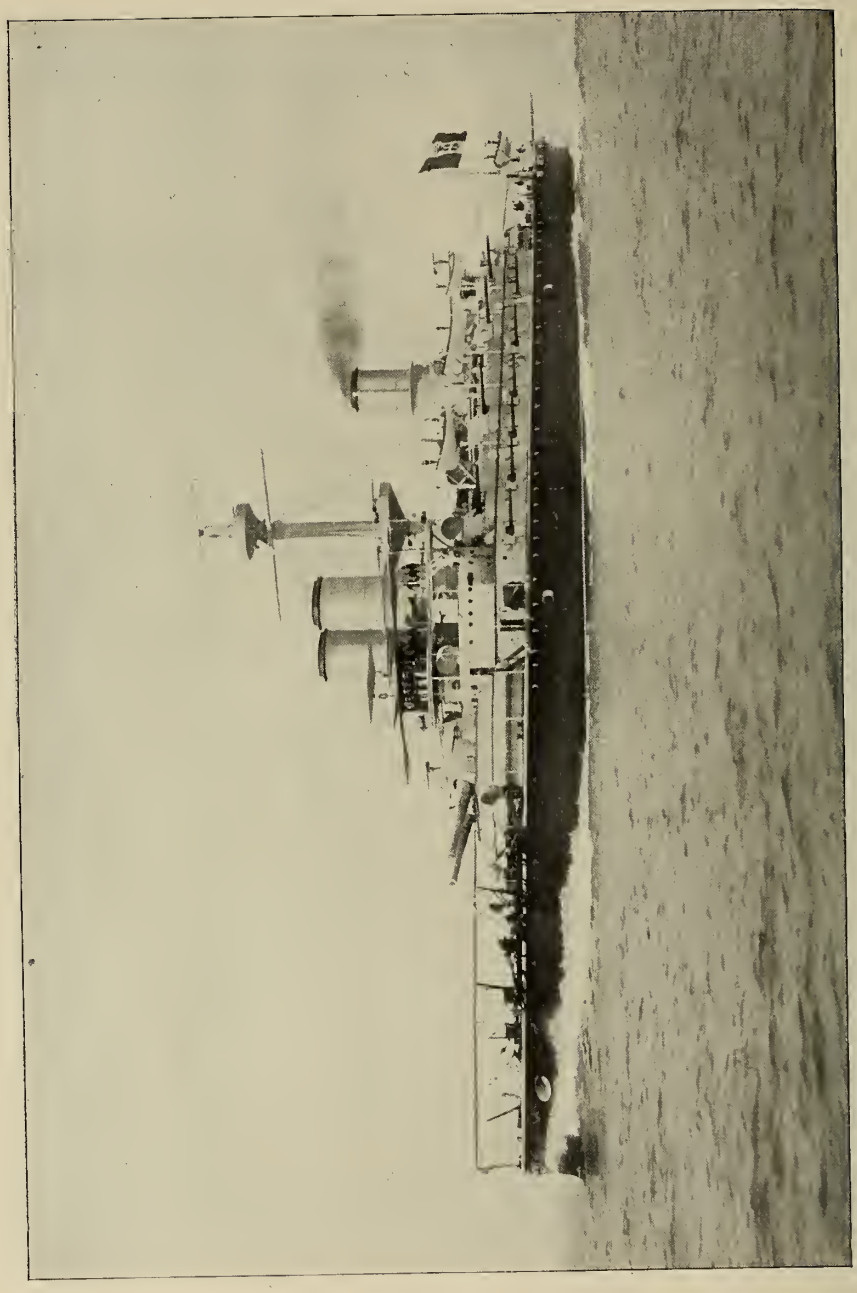
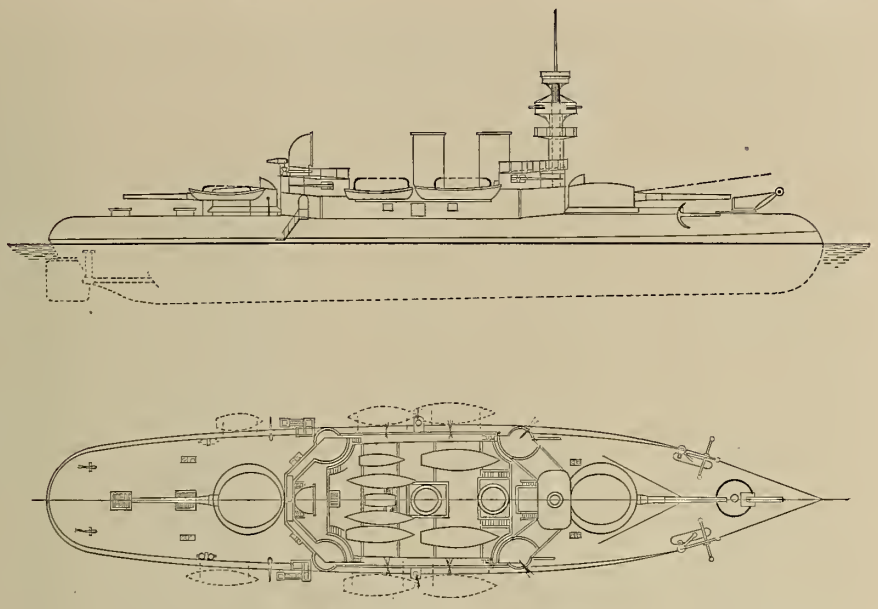
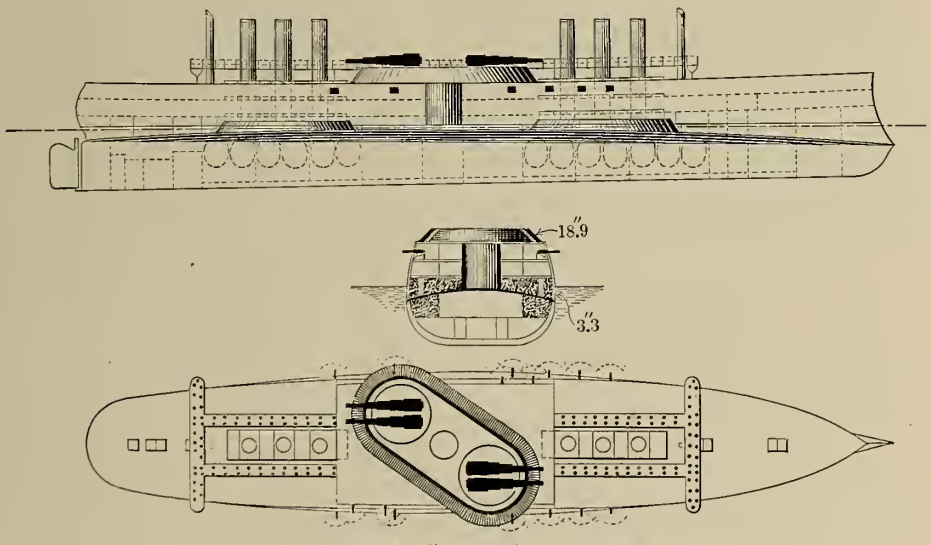


THE "SARDEGNA," OF THE ITALIAN NAVY.

its guns, weighs about 2500 tons, "and, therefore, we see a ship, not ironclad, carrying on her hull the equivalent



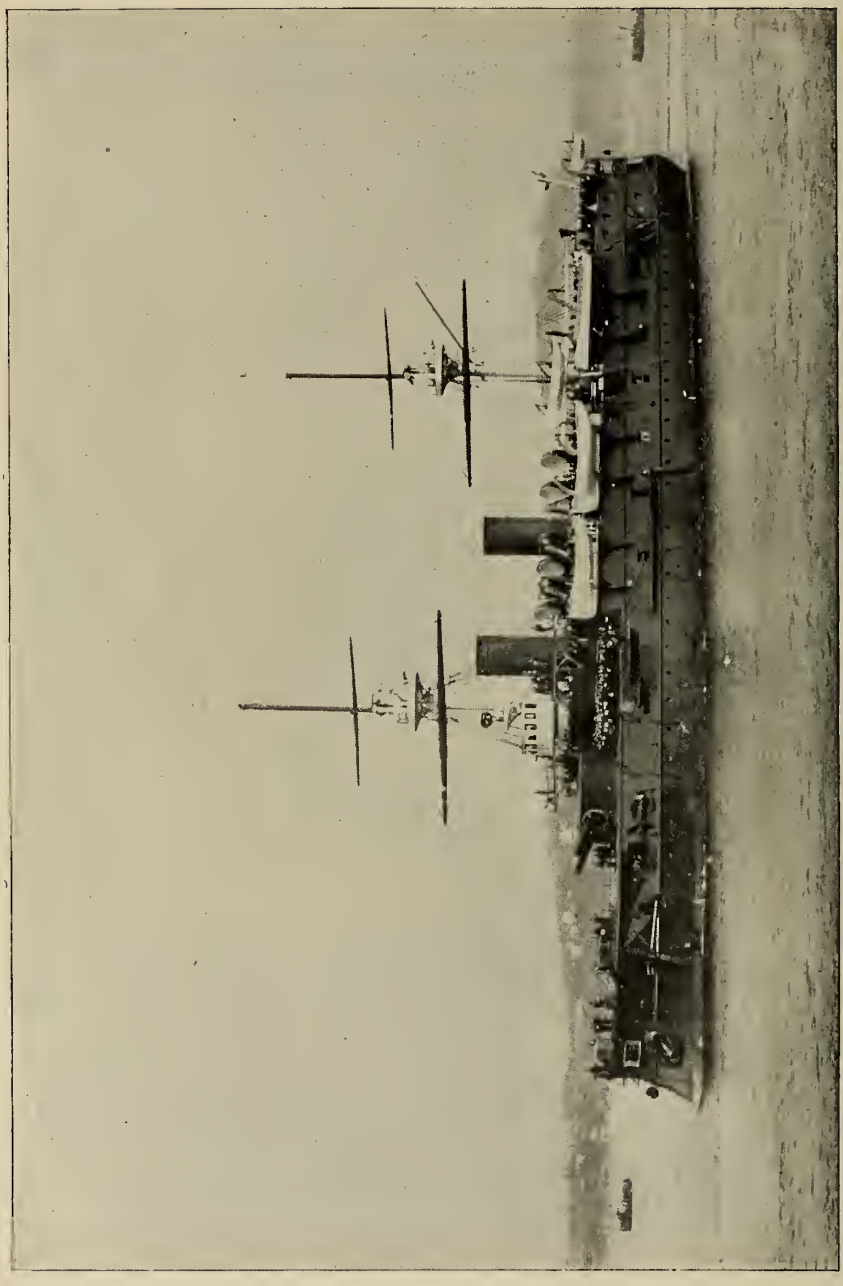
THE FRENCH BATTLESHIP "JEMMAPES."



THE ITALIAN BATTLESHIP "ITALIA." 13,900 TONS, 17.6 KNOTS.

tubes. In no country has more originality been shown in war-ship design.

Italy was one of the first nations to secure vessels of the *Esmeralda* or "ram-cruiser" type, previously noted. There are six of these of the *Giovanni Bausan* class. The latter has a dis-



THE RUSSIAN TWIN-SCREW BATTLESHIP "NICOLAI."

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placement of 3130 tons; length, 276 feet 6 inches; draught, 18 feet 6 inches; I. H. P., 6456; speed, 17.5 knots. Her armament consists of two 10-inch rifles, six 6-inch, four 6-pounders, and 6 machine-guns.

The most noteworthy experience of the Imperial German Navy with the ram was one of grievous disaster. On May 31, 1878, a squadron of three German ironclads was steaming westward hrough the Strait of Dover. The two she turned toward the shore, cleared them, and resumed her original course. Indecision retarded the *Wilhelm's* action, and, when she, too, turned toward the shore, it was to find the *Kurfürst* lying full across the path. Going at 6 knots, she struck the turret-ship on the port side, abaft the beam, her ram ripping up and forcing in the plates and armour.

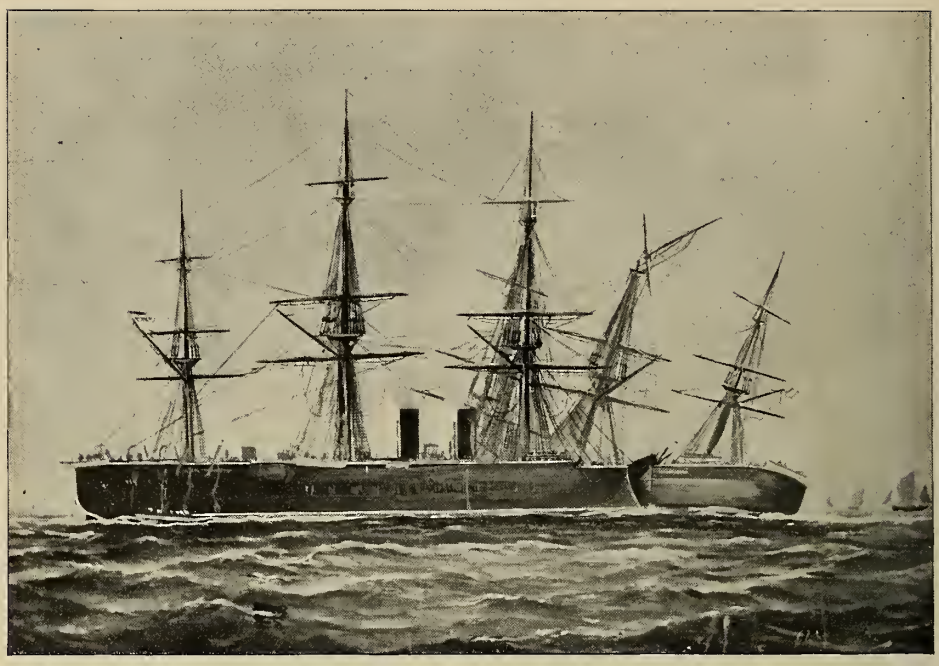
Heeling over, the *Kurfürst*, which had been steaming 9 knots, still forged

THE GERMAN IRONCLAD "GROSSER KURFÜRST," SUNK BY COLLISION IN THE ENGLISH CHANNEL IN 1878.

leading vessels were almost abreast and not much over 100 yards apart. They were the flagship *König Wilhelm* and the *Grosser Kurfürst;* the former, an armour-belted broadside frigate of 9600 tons; the latter, a ship-rigged double-turreted vessel of 6600 tons, carrying 29 officers and 497 men. The *Kurfürst* was to starboard of the *Wilhelm* and nearer the British shore.

As with the *Vanguard*, sailing vessels brought confusion and wreck. Two, from landward, crossed the bows of the ironclads. Meeting the *Kurfürst* first, ahead, breaking and bending the spur until it cleared the great rent in her side. Righting for a moment, she settled quickly to port, lay down on her beam ends, and, five minutes after the blow, she sank with a roar, leaving a fleeting cloud of steam to mark the spot, while the hungry suction and the entangling rigging drew with her many men.

The *Wilhelm*, too, seemed about to founder. Her ram was twisted and displaced, her heavy stem was fractured, and the joints of her plating were opened



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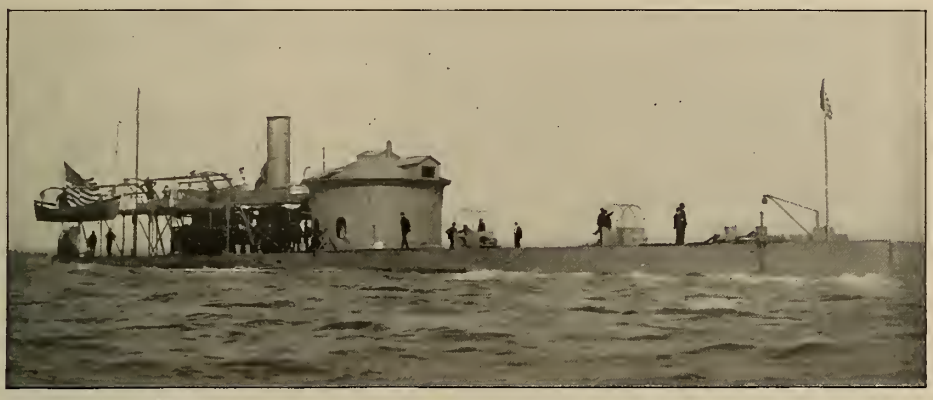
THE COLLISION BETWEEN THE "KÖNIG WILHELM" AND "GROSSER KURFÜRST" IN THE ENGLISH CHANNEL, OFF FOLKESTONE, ON MAY 6, 1878.

so that the sea flooded her bow compartments. The pumps were started and a sail was finally gotten over the leak. Then her boats were lowered to join those of the *Preussen*, the remaining vessel, in saving their drowning comrades of the *Kurfürst*, with which ill-starred ship six officers and eighty-one seamen found a grave. In analysing the action during this collision, Sir E. J. Reed has said:—

"The ramming ship took the other ship obliquely and both were at speed. The underwater point of the ram, which had great advancement, was seized, as it were, by the ship rammed and the armour which came to back up the stem at the water-line became a fulcrum. Consequently the momentum of the other ship, acting at the point of the stem, tended to, and did, turn the whole stem about the armour ends."

(The concluding portion of this article, devoted to the ram in the United States fleet, and comprising many additional illustrations, will appear in the July number.)



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A RELIC OF THE AMERICAN CIVIL WAR. THE OLD U. S. MONITOR "NAHANT."

MODERN SHIPS OF WAR.

A Brief Review of Different Types

By Lieutenant-Commander Richard Wainwright, U. S. N.

AT one of the recent meetings of the United States Naval Institute, Lieutenant Commander Wainwright presented a comprehensive paper on "Our Naval Power," in the course of which he compared at some length the different types of war vessels in modern service. From this review the following extracts have been made. They are of special interest at the present time when modern warships are undergoing their first actual service tests in the war between Spain and the United States.—THE EDITOR.

All naval powers appear to be agreed upon the necessity of three broad types, viz., battleships, cruisers and torpedo boats; but armoured vessels are constructed upon largely varying designs, so that there are not only numerous other types besides battleships, but there are many vessels that are placed in one type by some authorities and in another type by others.

The line between battleships and armoured cruisers is far from distinct. Again, heavily armoured vessels differ so in their steaming radii as to range from vessels fit for little besides harbour defense, through coast defense vessels, to sea-going battleships. Cruisers are so varied in design as to furnish examples to suit the most erratic fancy. Torpedo boats range from destroyers of about 350 tons to small launches. Besides these there are vessels designed for special purposes, such as rams, dynamite cruisers, etc., etc.

The question of the necessity of building battleships has been raised frequently. The strongest opposition to them is centered in France, and Admiral Aube has a large following; but

BY PERMISSION OF THE FINE ART SOCIETY.

H. M. S. "CONDOR," COMMANDED BY CAPTAIN LORD CHARLES BERESFORD DURING THE BOMBARDMENT OF ALEXANDRIA, JULY 11, 1882.

they have been unable to control the building policy of that country for any extended period of time, and France continues to build battleships, although the designs are somewhat controlled by similar ideas to those that would stop their building.

In analysing the many arguments raised in France for and against the building of battleships, the ruling idea that appears to permeate those from the new school is that there is one type suitable for the strong naval power and another for the weak; that France cannot afford to build and support such great fleets of battleships as Great Britain has built and is building, and therefore should put her faith in fast cruisers and torpedo boats; that there is one set of rules of strategy for the strong and another for the weak. Similar ideas led to the American policy of building gun-boats instead of ships of the line and frigates, and has led to the building of many harbour defense vessels.

Such ideas can prevail only because of a thorough misconception of the uses of sea power and the history of sea fights, and restricts the area of the influence of sea forces, so as to make them little more than adjuncts to land forces. They limit the final operations of battleships to attempting to knock down forts, and would make the destruction of a great coast fortress valuable, even though it belonged to a country without naval or merchant marine. In other words, they fail to see that the true value of a fortress is to protect the inlet and outlet for trade, the vessels carrying the trade, the vessels protecting the trade, and the supplies, munitions of war, repair shops, etc.

Without the vessels the fortress loses much of its value, and with the vessels cooped up within its protection its value is measured by the force of the enemy required to close its mouth. If they build any battleships they would build them to protect their coast, and they build fortresses to protect their battleships. The problem of selecting sites for fortifications on and near the coast line does not differ greatly from that of selecting them in the interior. Few engineers of the present day would think of designing immense fortresses with the idea of safeguarding an army inside. The example of Metz would be sufficient alone to prevent like errors. Why then Bazaine our fleets? Fortifications are designed to strengthen portions of the line of defense of an army, and to protect its supplies, munitions of war, and lines of communication, but not to enclose it. The value of an army is mainly dependent upon its mobility, and, although fortifications may be built around a city to strengthen its defense, the army that should seek refuge within would be partially defeated, its value for the time seriously diminished, and even the defense of the city weakened. So with coast and harbour fortifications; they should be designed to strengthen the lines of defense of the battle fleet and to protect its supplies, etc. They should also be designed to protect cities and harbours, and usually these would include points of supply. But the battle fleet, like the army, should have room to manœuvre even when fighting on the defensive.

Battleships are not designed to attack land defenses, but to meet other vessels on the sea; and, while they may at times successfully bombard fortifications, they will do so only under exceptional circumstances, and will need land forces to succeed in extensive operations.

The greatest blow to the adherents of battleships has been struck lately by Admiral Colomb. The blow is severe more because of the high reputation of its author than from the weight of the argument. Admiral Colomb is one of the most advanced thinkers on naval subjects, and, in my opinion, his deductions from history are better guides than those of any other modern writer. This makes his predictions as to battleships the more surprising.

What might be brushed aside if uttered by other men requires careful consideration when it comes from the mouth or pen of Admiral Colomb. In this case it seems that he has plainly placed himself on the side of the de-

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THE UNITED STATES MONITOR "PURITAN."

stroyer as opposed to the battleship, and that he believes it is time for Great Britain to cease building large battleships, that an entire change in type is necessary, and that something similar to the destroyer type should take the battleship's place. He assumes that the battleship has reached its final stage of development, that the type has reached its highest point of efficiency, and that the logical deduction from this assumed fact is that a new type must be evolved to fight in the line of battle. This new type he seems to think will be of the nature of a modified destroyer. He seems to think that a number of destroyers, whose aggregate cost would be less than the cost of one battleship, would be more than a match for her.

If there is any one thing more than another for which Admiral Colomb is justly celebrated it is his power of predicting the future and guiding the present state of naval affairs by lessons drawn from the past. One can readily imagine how he would have scathed an advocate of a policy of building small vessels to take the place of the great vessels of the line, and what ponderous blows he would have aimed at his adversary had he not been imbued with ideas that have forced him to take the side of small vessels.

Under other circumstances what admirable examples he would have drawn from history to show the necessity of battleships, and how he would have shown that in each change of design the logic of events forced the building of greater vessels. Now he is limited to one lesson of the past, that is, when a type approaches the point of perfection

a new type better adapted to the modified circumstances must be developed. One cannot cease to regret that a writer so powerful in argument should be found arrayed against the battleship.

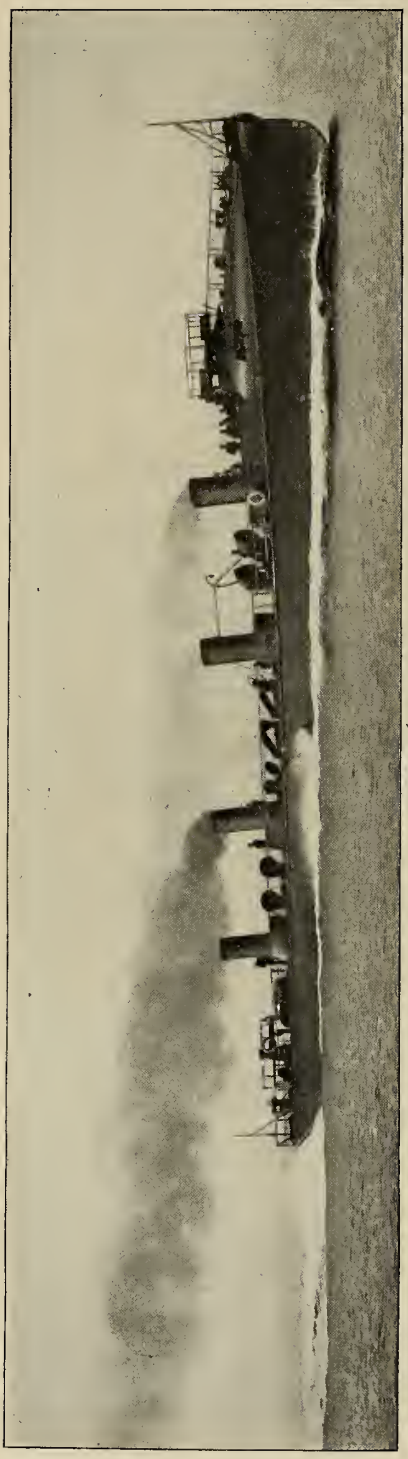
One of the strongest examples of history that can be brought forward on the side of the small vessel is the defeat of the Spanish Armada. Here the small swift vessels of the British were more than a match for the large unwieldy vessels of the Spanish, yet Great Britain and the maritime world did not draw the false conclusion that smaller vessels were the best—they modified their vessels of the line so as to make them sufficiently powerful to overwhelm a large number of the smaller vessels.

There were other things that led to the defeat of the Spanish Armada, but the small swift schooners of the British were the most important factors. They could choose their position so as to inflict the greatest injury to the Spaniards while receiving the least harm. Their low sides made them difficult to hit, and their power of beating to windward enabled them to move around the unhandy galleons at will, when there was sufficient wind. Their armament was superior to that of the galleons, and with some little increase in calibre of their guns they would have occupied the same position towards the ships of the line that the destroyers do to the battleships at the present time.

The galleon was improved. The sails and spars were so improved as to permit of the square rigged vessel making very fair work to windward, and the armament was so improved as to insure sinking the schooners at a single broadside. Each great change in type has resulted in an increase in the size of vessels designed to fight in the line of battle, from the introduction of sails, through that of steam, up to the mastless ironclad It would seem as if the limit in size had been reached, at least for the present; but it is going very far to assume that the present type has neared its highest point of perfection.

The present position seems to be this —that the small size and great speed of the destroyer, together with the power of its weapon, make the destroyer a most formidable enemy to the battleship. Many consider that at night-time several destroyers would be almost certain to defeat a battleship, and possibly

THE GERMAN TORPEDO BOAT DESTROYER "MAGNET." BUILT BY F. SCHICHAU, EIBING, GERMANY.



THE BRITISH TORPEDO BOAT DESTROYER "LYNX," BUILT BY MESSRS. LAIRD BROTHERS BIRKENHEAD.

in the day-time. Admiral Colomb appears to advocate a vessel somewhat larger than the present destroyer and with some armour. If destroyers are designed of over 350 tons displacement they must be of inferior speed to the present ones (with the engines and boilers as at present designed), or else they must sacrifice a greater percentage of displacement to their motive power than is sacrificed in those of 300 to 350 tons.

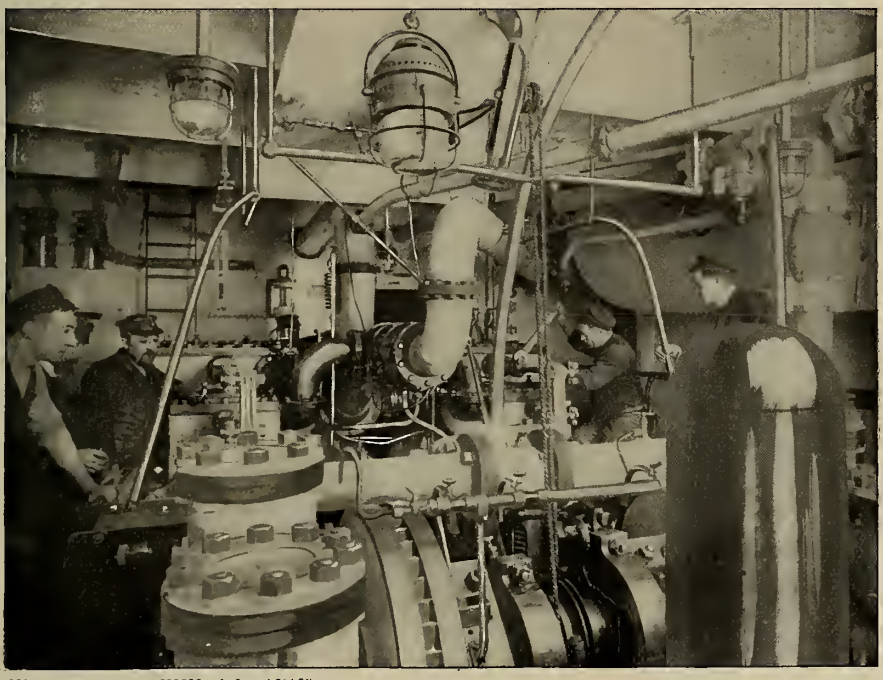
It has been pretty conclusively proved that for the same speed a smaller percentage of the displacement is required for the motive power in vessels of about 300 tons than in any other displacement until quite high figures are reached; so that, even without armour, large destroyers must have less speed than those of the present size. It would require considerable armour to protect against 12-pounders, although comparatively light armour would be sufficient to keep out 1 and 6-pounders. The larger destroyers would lose much of the invulnerability of other torpedo boats due to their small size.

The modern destroyer is a very wonderful weapon and admirably suited to the purposes for which it was designed, —the destruction of torpedo boats; but it must have its limitations, as have other war-like instruments. The destroyer is not the first weapon that, in the earlier stages of its development, was expected by its ardent admirers to revolutionise naval warfare, that is, was to change completely the design of vessels fit to fight in the line, but it is surprising to find Admiral Colomb apparently arrayed on the side of those predicting a revolution.

The torpedo and ram each had its day, each made its mark on the designs of the times. They created no revolution, but they did force modifications in design. The gun regained its ascendancy over the ram and torpedo, and the torpedo boat was limited by its vulnerability to operating in the dark or in thick weather, and by its endurance to operating at short distances from its base and in smooth water. Now arises the destroyer; it will have also its effect

on the design of battleships; it will find also its limitations.

The battleship is not well suited to attack land defenses, and when well designed and of sufficient strength, fortifications limit the area of a battleship's operations. Its area of operations may be limited also by light-draft rams, as they would prove most formidable at points where vessels of heavy draft were confined to navigating narrow channels.



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THE HYDRAULIC PUMP ROOM ON H. M. S. "RESOLUTION."

Torpedo-boats limit the area of operations of battleships, in that they become dangerous in narrow waters and near the coast, in darkness or thick weather. Submarine torpedo-boats may have also their limiting effect, in that they may make it dangerous for battleships to approach too nearly their bases even in daylight and in clear weather.

In all cases the probable danger to the battleship may be greater than the possible good to be gained by the attempt. But in the struggle for the command of the sea the battleship still reigns supreme, because the battle for the supremacy must be fought at sea by vessels capable of sustaining themselves at sea. This is the broad lesson to be drawn from all history, from all experience both ancient and modern.

The real difficulty that has confronted many students of naval history, and has served to mislead the advocates of special weapons, is the attempt to make general rules from particular cases. Seeing that many naval actions have happened near the land, they have exaggerated the importance of the narrow strip of water that adjoins the sea-coast, and have failed to realise that the force whose coast-line was attacked had been driven by superior naval power from the high seas. It is this exaggeration of the importance of the strip of water adjoining the land that has served to introduce erroneous theories into both strategy and tactics. If Great Britain commands the ocean, France will benefit little from holding Toulon and Brest, and if France commands the Mediterranean, Gibraltar and Malta will be of

A BOW VIEW OF THE UNITED STATES ARMOURED CRUISER "NEW YORK."

little utility to Great Britain. It may be advisable, in order to terminate a war, to attack fortresses and occupy ports, but the most important work has been accomplished when the enemy has been driven from the high seas.

The fall of Sebastopol was insured when the Russian fleet was locked up in the waters protected by that fortress; and with all the glory gained by Todleben for his defense of Sebastopol, he might have served his country better had he retired from its walls, in place of furnishing by his energy and science a force sufficient to hold it, and thus inducing Russia to diminish her resources by attempting to maintain a relieving army in the Crimean peninsula unaided by a fleet. In warfare on land fortresses have often been mistaken for the real objects of war, and the land forces, that otherwise might have marched to victory, wasted in their reduction. In naval warfare the same errors may be made. Farragut would never have occupied his present place in history had he wasted his resources by attempting to reduce the forts below New Orleans or Mobile.

If it be true that the field to be contested by warships is the high seas, then surely the battleship must be a vessel capable of keeping the sea,—a sea-going vessel. Weapons may be designed that still further limit its area of action, blockades made more difficult and the protection of commerce less certain, and both may require stronger forces than

at present; yet the force superior in strength and energy, if properly handled, must win. The American War of the Rebellion has been often quoted to show the difficulty of maintaining a blockade, and long lists of blockade-runners who have successfully eluded the blockaders are shown to prove how incomplete the blockade was; but does any one imagine that the efforts of the blockade-runners had any vital effect on the war? Can blockade-runners subsist a moderate steaming radius when proceeding at a moderate speed; but should they meet an enemy at sea, at a good distance from land, they would be unable to use their high speed unless they relinquished all idea of again reaching land.

If they were met by an enemy near the end of, to them, a long voyage, they would not have sufficient coal for high speed. And they could not remain off a port for any reasonable time and yet

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AMONG THE ENGINES ON BOARD H. M. S. "RESOLUTION."

armies, or the gains of a host of adventurers serve to replace the profits of legitimate commerce? Many were the British vessels that fell victims to American privateers in the war of 1812, and there were other enemies striking at the same prey; yet the commerce of Great Britain continued to increase while that of the United States faded away.

The great advantage possessed by the destroyers, besides their small size, is the very high speed of which they are capable; but they can maintain this high speed for only a short time. They have have sufficient coal to utilise the most important feature in their design,—high speed. Again, destroyers must be small-sized vessels, and therefore must lose their speed rapidly, as compared with large vessels, in a rough sea. In fact, except under unusual circumstances, a flotilla of destroyers must fall victims to large vessels on the high seas.

Any one who has closely watched the history of the many destroyers now afloat must be convinced that they are frail boats,—far too frail to allow of reliance being placed upon them in

emergencies that require them to operate at a distance from their base. Weights have been so fined down that accidents are numerous, and the best of them require overhauling after a comparatively short experience of high speed. It would seem as if the function of the destroyer having been exaggerated so as to include the destruction of battleships on the high seas as well as the destruction of torpedo-boats, an attempt has been made to increase desirable qualities beyond the limits inherent in the design, and thus reliability and consequently efficiency have been sacrificed.

The battleship may be improved in several directions so as to make the destroyer's fate more certain; and yet the battleship may find its area of action still further limited by the advent of the destroyer, although employed within its legitimate sphere. But it would be a serious error for any maritime country to neglect building battleships.

An inspection of the armament of various battleships will show a tendency of late years to decrease the number of the lighter guns carried. This is not an improvement, and an increase in calibre does not make up for a decrease in the number of shots per minute. It may be necessary, in view of the efficiency of the destroyer type, to increase the number of small guns, even if positions must be selected for them that would prevent them from being used under many circumstances, such as in a rough sea or when the larger guns were being employed,—in fact, in positions where they would be used only to repel torpedo-boat attacks.

In torpedo boats two types are gradually being settled upon by naval powers,—the destroyer type, and a smaller, slower type, with a smaller steaming radius.

There is no settled type of cruiser, and each vessel appears to have been built to fill some pet idea of its designer. What is most essential is a type of vessel that will fill the place of the old sailing frigate and be the eyes of the battle fleet. There are two special objects to be accomplished by vessels of such a type in connection with the battle fleet. One is to seek information of the enemy's fleet, and the other to mask the movement of their own fleet. The manœuvres of the great naval powers have been somewhat misleading on this question. Each side in the manœuvres has usually had good information as to the composition of the fleet of its opponent, so that a sighting cruiser would be satisfied often with reporting the amount of smoke, and at the most with counting the vessels composing the fleet. In real war, however, it would be necessary, under most circumstances, to ascertain something of the real strength of the fleet, and draw sufficiently near to distinguish battleships from cruisers. Again, the attacking fleet has seldom used its cruisers as a real mask, but has dispersed them in search of the defending fleet.

In real war there is more likelihood of hard fighting than has been shown by the manœuvres, and the ordinary so-called protected cruiser is but poorly fitted for hard fighting; too little room is left for skill, and when two cruisers of approximately equal strength meet in battle, both of them are likely to be lost to their fleets. Some side armour as a protection to their buoyancy is necessary, and yet they should be faster and have a greater steaming radius than a battleship.

This, it has been claimed, will lead to excessive displacements and will make the cruisers almost, if not quite, as expensive as battleships; but this large displacement has been shown to be unnecessary, although armoured cruisers have been enlarged to endeavour to fit them to fight in the line. Something near the ideal type, according to my ideas, has been reached in the Argentine armoured cruiser *San Martin;* and I believe such a vessel more nearly represents the frigate of old than any other type of vessel. Here the desired qualities have been secured with a displacement under 7000 tons.

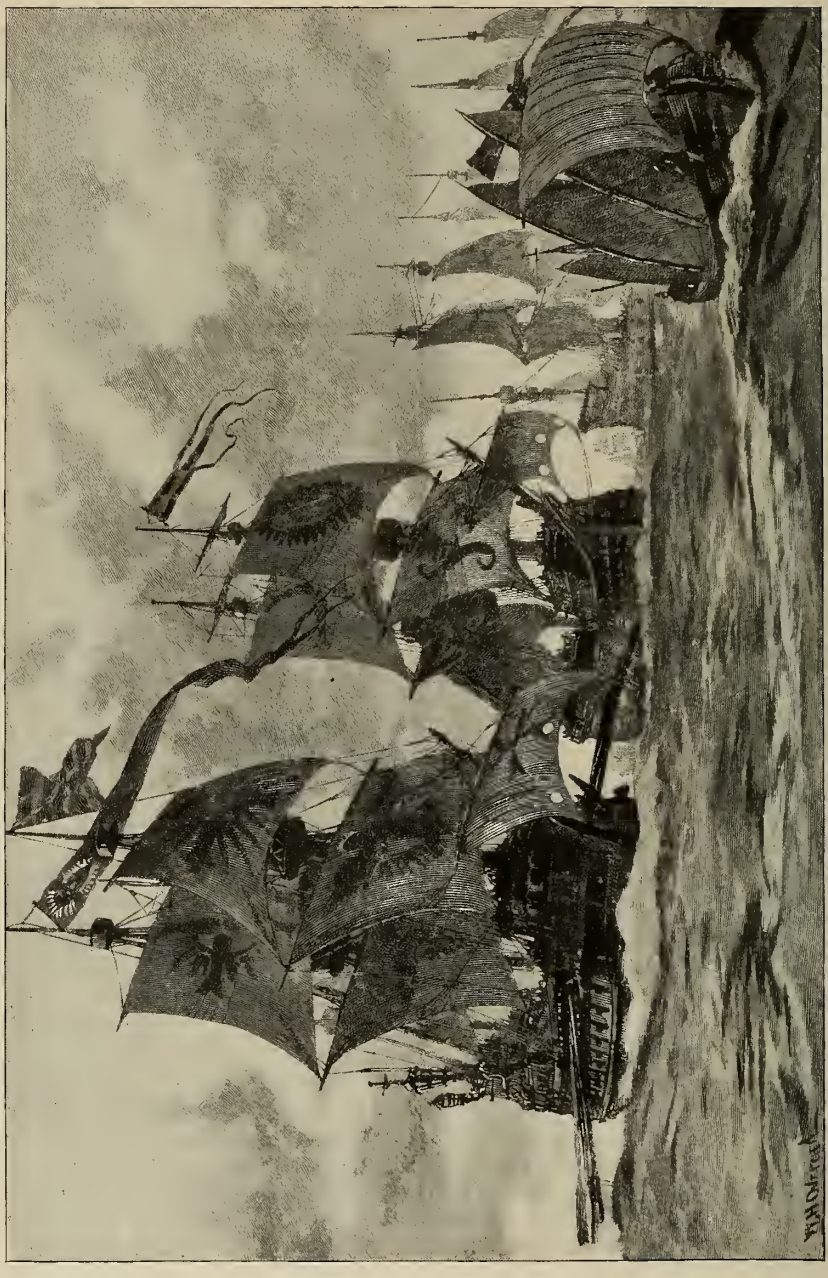
THE DEFEAT OF THE ARMADA IN 1588.

By Charles N. Robinson.

FROM an historic point of view, and with Spanish war thunder now echoing over the seas, there are few things more impressively interesting than that Spanish expedition of three hundred and more years ago, designed to invade and lay Great Britian under tribute to the Spanish crown. At the time of the three hundredth anniversary of the memorable events attending that naval enterprise there appeared in the Illustrated London News the picturesque account of the defeat of the Spanish Armada, which has been reprinted in the following pages, and with it have been reproduced as well the illustrations published at that time. They form to-day a chapter of the world's history which appeals to every one.—THE EDITOR.

An invasion of Great Britian, the actual landing of a foreign foe upon its shores, might well appear to the majority of its inhabitants to-day an event so unlikely, so improbable, as almost to pass belief. The memories of many glorious victories, the extension of civilisation, a happy exemption from the horrors of war, and the enjoyment of long years of peace and prosperity, have together contributed to make the mere notion of such a calamity overtaking us difficult, indeed, for the present generation of Englishmen to realise.

Far otherwise was it with their ancestors towards the end of the sixteenth century. Our countrymen of that great epoch in Britain's history which is marked by the sovereignty of Elizabeth Tudor, although they had not actually experienced the iron grasp of an enemy, had yet but a short while been emancipated from a thraldom and tyranny not the less galling that it was mainly of home manufacture. Proud and jealous of their new-found civil and religious liberties, prouder still of their growing strength upon land and sea, and not unmindful of the destiny which seemed in store for their descendants, the people of that period had around them ample evidence of the facility with which nations, stronger, more numerous, and, apparently, enjoying far greater security than themselves, could pass under the



THE ARMADA COMING UP THE ENGLISH CHANNEL.

yoke of the conquerors of Mexico and Peru. So when, at length, they knew that the vast strength and resources of the most powerful and the richest monarch in Europe, supported, too, by the promises, the blessings, and the far-reaching machinery of the Pontiff of Rome, were about to be exerted to crush their country, they must have been less than Englishmen had they not sunk their discords and differences and stood as one man against the common enemy.

How they equipped themselves to resist the danger, how they combatted the forces sent against them, and how, under Providence, they saved this land, and, indirectly, all Northern Europe, from bondage, preserved their faith and liberties, both spiritual and temporal, and handed down, untarnished and unsullied, the honour and prestige of the nation, forms a story the recital of which cannot fail to stir even the coldest and most apathetic amongst us. To the happy termination of this momentous crisis in our history, the Commercial and Colonial Empire of which we are so justly proud mainly owes its being.

With the causes which led to the setting forth of Spain's hostile demonstration, it is not our intention to deal at length. It is, however, a mistake to suppose that religious animosity or sectarian motives were chiefly, or even directly, connected with its inception. No stronger grounds for an appeal to arms could have been needed than the recognition and support given by Elizabeth to the deeds of Hawkins, Drake, and other seamen, who, from the Spanish point of view, were pirates and smugglers, fit only for the hands of the hangman or the inquisitor. The conquest of England was considered a just and desirable enterprise, and copious testimony exists that long prior to the actual attempt preparations were being made to assail and overwhelm the island and "its brood of vipers."

The Spanish preparations were most complete. The total number of craft of all kinds composing the Armada was, probably, 130; but a few of these never crossed the bay. At least sixty were galleons of huge size and strength, ranging from 700 up to 1250 tons burden. They were not, however, primarily built for war purposes, and the proportion of guns they carried was, as compared with their size, not large. But being intended for long voyages, their upper works were high out of the water, and their main timbers three feet or four feet thick. One hundred years before, the Portuguese galleons, under Diaz, had doubled the Cape of Good Hope, and, with the conquest of Portugal, some of the finest ships in the world passed into the Spanish king's hands.

It was the Portuguese galleons that formed the van-squadron of the Armada, the largest of them mounting, perhaps, fifty guns, and many of these of small calibre. In the case of the hired ships, except the heaviest Levantine galleons, the proportion of guns to tonnage was still smaller. Usually sailing in still water, they did not carry numerous crews, but now they were crammed with soldiers to an inconvenient degree.

Of the second class of ships, called galliasses, there were four in the fleet. These were proper war-ships, and certainly did their share of the fighting. Like the galleons, they were three-masted vessels, but were also propelled by oars, to pull which they carried a large number of galley-slaves. Their prows and sterns were furnished with heavy cannon in high castles, and they carried smaller cannon on the broadsides, in ports between the rowers. The two larger each carried nearly 300 soldiers, and over 100 sailors, with 350 slaves to row. There were also galleys with one or more tiers of oars a-side, many merchant and storeships, caravels, and urcas.

The *personnel* of the flotilla consisted of over 30,000 persons, including 18,000 soldiers, 800 sailors, 2000 galley-slaves, and a numerous hospital staff, assisted by 180 priests of various Orders. The armament was of 2000 guns; a few may have been 64 or 32-pounders (cannon or demi-cannon), but by far the greater number were 10, 6, or 4-pounders (demi-culverins, sakers and minions). The whole force was victualled for six

QUEEN ELIZABETH OF ENGLAND.

months, a large sum of money was taken in the fleet, and the orders for preserving discipline were usually strict. In the vicinity of Nieuport and Dunkirk, Farnese, the Prince of Parma, had assembled an army of 30,000 foot and 4000 horse, picked troops ready to be embarked in scores of flat-bottomed boats and transports, and conveyed across to Margate and Deal so soon as the English and Dutch ships should have been swept from the narrow seas before the imposing array of the "Invincible" Armada.

Of the officers in charge of these vast and apparently overwhelming expeditions, Santa Cruz had seen more service than any naval commander out of England; while Parma was reckoned the first military leader of the time. But Parma never set foot on English soil and Santa Cruz died in February, before the Armada was quite prepared for starting; the Duke of Medina Sidonia, his successor, had little to recommend him for the post, save blue blood and personal courage. He had, however, some exceptionally able seamen and commanders as his advisers.

Don Juan Martinez De Recalde, vice-admiral and capitan of the Biscayan Armada, was both, and proved it during the whole of the unlucky cruise. He was fortunate, like his chief, in being able to return; but he died shortly after he landed. Don Diego Flores De Valdes, general of the fleet of Castile, had already served with distinction afloat. He it was who recommended the burning of the English fleet at Plymouth; and he it was, also, who lost heart altogether after the great fight off Gravelines. Don Pedro De Valdes, admiral of the Andalusian Armada, had commanded a fleet in northern waters, and it was hoped that his local knowledge would prove valuable; but his ship, *Nuestra Senora del Rosario* (commonly called the *Capitana*), was the first to be captured and himself taken prisoner.

Other commanders of whose exploits we hear are Don Miguel De Oquendo, a dashing and chivalrous officer, in opposition to whose advice the retreat by the North Sea was made; Don Martin De Bertendone, whose flag-ship, the *Ragazona*, was always in the thickest of the fighting (he commanded the squadron of hired galleons, among them some of the finest ships in the Armada);

PHILIP II., KING OF SPAIN.

THE ALARM. LIGHTING THE BEACONS.

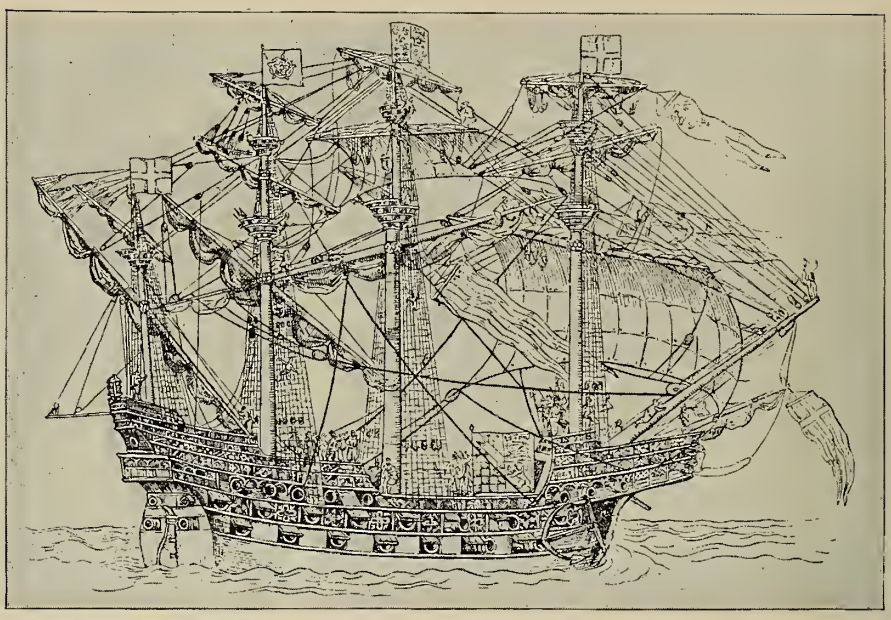
and Don Hugo De Moncada, who had charge of the four galliasses, and who lost his life when his ship was taken off Calais.

In command of the land forces embarked was Don Alonzo Da Leyva, flying his standard in the Rata Coronada, a veteran general who, as a youth, had crossed sabres with the Moors, and had since seen service in many a land and sea battle. To his charge, we are told, were committed most of the high-born youth of Spain who sailed in the expedition. This gallant old soldier, after being thrice wrecked, was eventually drowned, with most of his companions, on the coast of Ireland.

In England a commission had been convened of noblemen and gentlemen, as well as the most experienced naval and military officers, "to sett doune such meanes as are fittest to putt the forces of the Realme in order to withstand any invasion." It is worthy of note that, in the opinion of the experts of these days, the only sure means of preventing invasion was in the maintenance of an invincible navy. At the same time precautions were to be taken on shore, in case the enemy should land at Milford, Plymouth, Portland, the Wight, Portsmouth, the Thames or Harwich. Militia and volunteers in great numbers were embodied, and commenced training in the use of arms; camps were laid out and fortified; while on every high place beacons and bonfires were prepared for lighting to give information of the advent of the foe and summon the defenders of the State.

These preparations were confined to no single part of the country or to any particular class or creed. Many places, like the city of London, came forward to do their duty by assisting, not only with land, but with sea forces,—raising loans, finding ships and men, victualling and arming them. Everywhere there was but one desire apparent; and Protestants and Catholics, the classes and the masses, vied with each other in displaying one mind,—to take up arms, and, if need be, to lay down their lives in the defense of their rights and privileges against the threatened tyranny of Spanish rule.

To give them their due, there were many among the gallant seamen and soldiers of the time who neither feared nor underestimated the Spanish power.



FROM A PRINT IN THE BRITISH MUSEUM.

THE "ARK ROYAL," THE FLAGSHIP OF THE BRITISH FLEET.

While the patriotic spirit which was aroused is well exemplified by the conduct of the pirate who is said to have walked into the hands of justice that he might give timely notice of the coming

LORD HOWARD OF EFFINGHAM, ADMIRAL OF THE BRITISH FLEET.

of the hostile fleet, at the same time the remark, which Sir Francis Drake is reported to have made when interrupted in his game of bowls on Plymouth Hoe, "There's time to win the game and thrash the Spaniards, too," is an instance of the contemptuous feeling in which the invaders were held by those best acquainted with them.

The bold merchant adventurers, buccaneers, or smugglers,—call them what you will,—who had fought and thrashed the Don afloat and ashore—not without getting hard knocks in return—saw in the huge armament then entering English waters, if not fresh opportunities for plunder and prize-money, at least a great chance to pay off old scores. They reckoned the slow, ponderous, badly-armed and overcrowded galleons at their real value, and never doubted for an instant the outcome of the maritime fray, so long as they could get a sufficient supply of stores and ammunition from the authorities.

The total number of ships in the Navie Royal was thirty, big and little,—the four largest being the *Triumph*, *Elizabeth*, *White Bear*, and *Victory*, all built from the designs of Sir John Hawkins, Treasurer of the Navy,—seaman, shipbuilder, and navigator,—a man, indeed, to whose fertility of resource and skill, as much as to the ca-

pacity of any other man of the time, must be attributed the victory which followed. Then, as for long afterward, there was no peace south of the Line, and every merchantman was forced to go about its business armed, while it was customary to call upon the seaports for their ships in war-time. So the numbers of the fleet were soon increased.

Altogether, the English fleet consisted of 197 vessels, many of which were mere pinnaces and coasting craft. The force embarked was about 15,000 men; but the proportion of seamen to soldiers in each ship was much greater than in the invading force. Holland also sent a contingent of ships, under Justin of Nassau. These Dutch ships do not appear to have met with the vessels of the Armada, but they effectually did their work on the Netherland coast.

The English flag-ship was the *Ark Royal*, a vessel of 800-tons burden, carrying 425 men and an armament of which the following summary is prob-

"A TALL SPANIARD."

ably correct:—4 cannon (60-pounders); 4 demi-cannon (32-pounders); 12 culverins (18-pounders); 6 sakers (6-pounders); and some smaller ordnance. These last-named were styled port-pieces and fowlerhalls,—small guns made in two parts, the chambers being ready-charged, and placed in the piece

SIR MARTIN FROBISHER.

when needed. The largest guns were usually mounted as chase-pieces, in the stern; demi-cannon and culverins, in the broadside ports, which were frequently circular in shape. Sakers, minions (4-pounders), or falcons (2-pounders) were mounted on the quarter and forecastles, on blocks of wood or as swivel-pieces; while the smallest ordnance, sometimes called "murdering pieces," were placed on barricades inboard for use against boarders. From the tops also were used "fyrevorkes," of which the Spaniards were reported to stand in great dread.

The ships were gaily ornamented with carvings on their woodwork, their sternposts and figureheads being often works of art, beautifully carved, moulded, painted and gilded. Then, too, there were the great poop lanthorns, and from every conceivable point aloft hung the banners and "ancients" of the leaders and the national emblems. The length of these banners and pennons may be judged by that one which, in memory of this very event, was "set up in the great church of Leyden, in Holland, and being fastened to the very roofe, it reached down to the ground."

Some curious information about the cost of these flags is extant—as, for ex-

ample, we read that Henry Holesworth, of London, May 21, 1588, supplied fourteen flags of St. George of "fine beaupres" for the use of her Majesty's ships and pinnaces at Chatham, one at £4, eleven at £3, and two at 20s. the flag. John Heath, of London, also supplied two ensigns of silk, one for H. M. S. *Rainbow* at £5, 6s., 8d., and another for the galley *Bonavolia* at £8, 6s., 8d. William Ryford, of London, also provided forty-six streamers or pennants for the use of the *Ark Royal*, the *Victory*, the *Mary Rose*, and the *Swallow* at 20 pence apiece. Again, Lewis Lidyard, of London, had for 102 yards of calico, used for making two flags, stained in colours with her Majesty's arms, "to be worn at sea in the ship the Lord Admiral sailed in," at 9d. every yard, £3, 16s., 8d, and, moreover, for staining the said flags and bringing them from London to Queensborough, by Chatham, £6, 16s., 2d. The manning of the ships, whether of the navy or of hired or volunteer merchantmen, was most imperfect; pay was generally in arrears; and, sanitary arrangements being totally wanting, disease and sickness were rife.

The most illustrious and notable of the English sea-officers was Lord Charles Howard, of Effingham, Lord Admiral, as his father had been before him, a man of considerable experience at sea at the time of the threatened invasion. To his caution, coolness, judgment, and, in particular, his ability as a naval tactician, the victory in 1588 was, in no small degree, due. To understand the difficulties with which he had to contend, his correspondence must be read. The constant burden of it is, that while he had ships and men—the latter as good as any in the world, and ready to spend their lives in her Majesty's service—money, stores, ammunition, and provisions were all lacking. And so it went on to the end of the campaign. So far as concerned a constant attention to the details of his office, a zealous care for his men, and a courteous consideration for the advice of his counsellors (some of whom were more noted for temper than tact), the Admiral did wisely; and when the moment arrived to try conclusions with the enemy, he proved himself amply endowed with true courage and valour.

The four men whom Lord Howard chose as his advisers, and of whom he writes—"the worlde dothe judge to be men of the greatest experience that the realme hathe," were Sir Francis Drake, Captains John Hawkins, Martin Frobisher, and Thomas Fenner. Of these four, Sir Francis Drake has by some writers been made the central figure of the defeat of the Armada. His chief exploit was the taking of *Our Lady of the Rosary*, the *Capitana* of Pedro de Valdes. Drake's conduct on the Hoe at Plymouth, if the story is true, was hardly that of a zealous subordinate, wishful to give a good example to the men under him. Disobedience is generally charged to him also in the matter of carrying a light on the night of the fight off the Start. His conduct in the action of the Gravelines was that of an impetuous, brave, and daring officer, and he was indisputably a capital seaman and an intrepid commander; but he appears, possibly from old associations, to have allowed his lust for dollars to detract from the duty he owed to his chief and his country.

Captain John Hawkins came of a seafaring family. He was a Devonshire man, while Drake, also, was a native of Tavistock, and Frobisher hailed from the county of York; but all sections of the country may fairly claim to be represented among the sea-commanders on the eventful occasion. Hawkins's father was a famous shipbuilder of Plymouth, and well known as an expert navigator in the time of Henry VIII. Hawkins' son, too, Richard, who commanded the *Swallow* against the Armada, was noted as an able seaman, and, in his "Observations," has given us a most valuable record of the manners and customs of the Elizabethan sailors. Under Captain John Hawkins, Drake was trained; and many of the best sailors and navigators of the time had been in the forecastle, or officers with him.

Among the first and foremost of the distinguished seamen of his day was Martin Frobisher. His indomitable

bravery and bulldog courage in the fight off Portland was rightly recognised by the honour of knighthood conferred on the following day. Frobisher's true claims to the gratitude of all Englishmen have lately received attention at the hands of Rev. Frank Jones, whose valuable and interesting account of the life of this gallant seaman and discoverer deserves to be widely known and read. Of the brothers Fenner, Thomas, Edward, and William, who, respectively, commanded the *Nonpareil*, *Swiftsure*, and *Aid*, little has been written and but little appears to be known. All these brothers did good and gallant work; and Thomas appears, from a letter of his which still exists, to have chased the flying Spaniards farther north than most of his brother commanders.

Lord Henry Seymour carried out his work with praiseworthy assiduity; particularly gallantly did he fight on the day of the battle off the Gravelines. Sir W. Wynter, his vice-admiral, an old and able officer, did excellent work the same day. He was Master of the Ordnance, and, nearly thirty years before, had seen service in command of a squadron against the French in the Firth of Forth. He came of an old and distinguished Gloucestershire family; and Captain Wintour, of Ryde—the proper spelling of the family name—was associated with Major Martin Frobisher, Mr. Stuart Hawkins, and Dr. H. H. Drake among the committee for the Trecentenary Celebration.

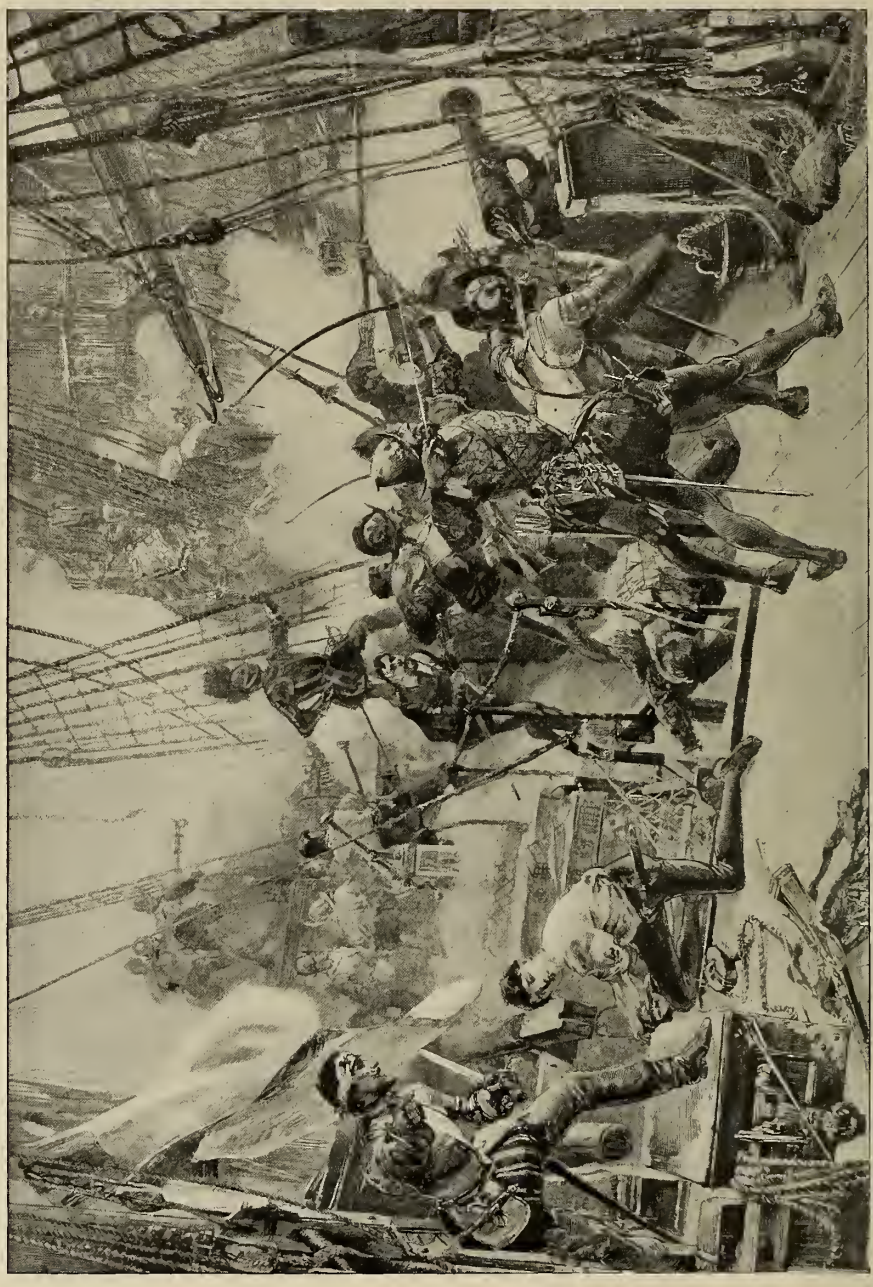
It will be interesting, before narrating the incidents of the sea-fight, to draw a comparison between these two forces—the Spanish and the English fleets. It is very generally believed that, in every respect, the Spaniards were superior; but this is now known to be an erroneous idea altogether. In numbers, owing to the division of the English squadrons, the Armada was superior; and, coming down to the distinctly fighting-ships, the totals, as given by Professor Laughton, were, of Spaniards, 62; of English, 49. But in manœuvring power, and in weight of metal, the advantage is shown to have been quite the other way.

Charnock lays great stress on the superior handiness and speed of the English ships, and Laughton, who has probably given more study to the subject than any one else, appears to have conclusively proved that in the matter of armament the Spaniards were also overmatched. Nor were these the only advantages possessed by the English, which, while they do not detract from the remarkable prowess and skill of the English commanders, bear out the naval historian's contention that no miracle or special intervention of Providence was required to insure victory to the English arms.

Our seamen were the most skilful and dexterous in the world. They were rough-weathered men, used to hardships, and living great part of their time with their lives in their hands. They knew their officers and were known to them. Each was proud of the other, and a comradeship existed between the quarter-deck and the forecastle entirely unknown in the Spanish service. Then they not only knew their officers, but they knew their ships, and how to handle them in all weathers and under most circumstances. As Sir Walter Raleigh and Sir William Monson tell us, they had introduced many improvements in rig, of which the Spaniards, who were principally "trade wind" sailors, had no knowledge.

The science of gunnery at this time was almost unknown, and archery formed a branch of it; but the Englishmen had made it a study, while the Spaniards despised it, regarding the sword as the more noble weapon. To this feeling and to the number of soldiers carried in the huge castles of their galleons may be ascribed their constant attempts to board. Altogether, we shall not be going beyond the mark in saying that, so far as the seaman's skill and the gunner's art are concerned, the Spaniards were utterly and entirely beneath comparison. At the same time, it must not be forgotten that during the first week's fighting, the numerical superiority of the Spanish to their assailants was something like six to one.

May 29-30, 1588, "La Felicissina



LORD HOWARD OF EFFINGHAM ON BOARD THE "ARK ROYAL," ENGAGING THE SHIPS OF DON ALONZO DA LEYVA.

Armada" sailed from the Tagus. With great pomp and circumstance the mighty fleet left, in charge of the Duke of Medina Sidonia, and could it have then and there proceeded direct to these shores history might have had a different tale to relate. But, in those days, sailors had to reckon with the wind and the weather, and these proved so tempestuous that the squadrons of galleons and store-ships soon separated, and it became impossible to proceed. Some were dismasted, one or two totally lost in the bay, and though a few of the ships are said to have gone on and sighted the Sicilies, all of them had eventually to put back and seek shelter in the Groyne. The damage done, the time lost in getting the ships together again and revictualling them, with other matters, were made reasons by a council of war at Corunna for urging a postponement of the expedition. Philip, however, was inexorable, and ordered immediate departure. And now a story reached Sidonia to the effect that Howard had laid up his ships for the season; it was, therefore, determined to stand boldly for Plymouth, and, if possible, surprise and burn the English fleet, and perhaps effect a landing.

July 12, a Friday, the Armada sailed with a fair breeze from Corunna. After a nasty passage, baffled by contrary winds and calms, and scarcely propitious of success, on Friday, July 19, they entered the Channel and sighted the Lizard, which they took to be Rame Head; so they stood off for the night. They had, however, been seen by Flemming and other scouts of Howard's, and the news was brought, as the story goes, to the captains, while they were playing at bowls on the Hoe.

It is this scene which Lucas has depicted in oils and Kingsley has described in "Westward Ho!" The latter narrative, inimitable as it is, tempts us to believe that matters may have fallen out as he sets them forth; but it seems more likely that the story had its origin in a desire on the part of some contemporary writer to emphasise, figuratively, the unreadiness of the English when the Spaniards made their appearance.

Stirring as that moment must have been to the inhabitants of Plymouth, the excitement with which the news was received throughout the length and breadth of England was even greater. From Land's-End to Cumberland the beacon fires blazed from hill-top and castle-battlements, the general call to arms sounded, and the troops marched to their allotted stations for the defense of the coast.

"Myselfe can remember," writes an eye-witness, "when upon the fyreing of the beacons (whereby an alarum was given), the country people forthwith ranne doune to the seaside, some with clubs, some with picked stones and pitchforkes, all unarmed, and they that were best appoynted were but with a bill, a bow and a sheafe of arrows; no captains or commander appoynted to direct, lead, or order them." The greatest enthusiasm was aroused, and every one hurried to take his part in the defense of the country. Short work, probably, the veterans of Parma and Leyva would have made of these unarmed, undisciplined mobs; but their ardour was indubitable, and the feeling of the countryside has been eloquently expressed by Macaulay:—

Night sank upon the dusky beach, and on the purple sea,
Such night in England ne'er had been, nor e'er again shall be.
From Eddystone to Berwick bounds, from Lyme to Milford bay,
That time of slumber was as bright and busy as the day;
For swift to east and swift to west the ghastly war-flame spread,
High on St. Michael's Mount it shone—it shone on Beachy Head.
Far on the deep the Spaniards saw, along each southern shire,
Cape beyond cape, in endless range, those twinkling points of fire.

In the Cattewater, then the principal harbour of Plymouth port, the excitement and agitation all through that night was feverish, indeed. The ships had to be warped out and got over to the sheltered anchorages under Mount Edgecumbe, ready to sail at daylight. Cawsand bay was protected from the prevailing wind, and in this bight many of the vessels lay all night. These, however, were but a small proportion, for several of the galleons had been partially dismantled for refitting, stores were ashore and men on liberty. So,

FROM PINE'S PLATES OF OLD TAPESTRY IN THE HOUSE OF LORDS.

CHART SHOWING THE COURSE OF THE ARMADA AND THE SEVERAL PLACES OF ACTION BETWEEN THE TWO FLEETS.

amid much bustle and noise, the ships were got to sea, some of them considerably undermanned, for the sickness was terrible among the crews.

On Saturday morning, Howard, having with him as many ships as were ready, stood away to the westward, hugging the coast, and found the enemy off Fowey, standing up the Channel with a fair wind from the southward and westward. We may suppose that the Dons were somewhat disconcerted to find that they had been unable to take the English fleet at a disadvantage, which, if they had only stood straight on the night before, they certainly would have done. As it was, Medina Sidonia, in the drizzling rain which fell throughout the day, sent a boat towards the land to make inquiries, and from some captured fishermen learnt his position, and that the ships he saw looming in the mist were part of the English fleet under the Lord Admiral. Meanwhile, Howard, seeing that the Spaniards were rapidly conceding to him that which he so ardently desired, — the weather-gauge,—troubled not to interfere; but, keeping a wide berth, hugged the land and watched the enemy.

Sunday, July 21, was a typical English summer's day. The sun shone out,

lighting up all the glory and the gilding of the castellated structures which came on slowly over the waves, brightening

SIR JOHN HAWKINS.

up the emblasonments of their sails, and making a big display of their many-coloured flags and pennons. It was an imposing spectacle, and, at this moment, many of the Spaniards might have thought themselves invincible; before evening they were to be further enlightened.

At early morning the wind drew round to the W. N. W., a still more favourable quarter for the defending fleet, and Howard now opened the ball with a warning shot from one of his pinnaces to demand the honour due to the English flag. Naturally, Sidonia paid no attention to this, and it was immediately followed by a general cannonade discharged by our fleet as they formed in line of battle. With their starboard tacks aboard they stood past the Spanish line, each ship pouring in a broadside as it neared an enemy. In the light breeze prevailing the English vessels probably went two knots to the Spaniard's one, and having given the van ships a taste of their metal, concentrated their efforts on the rear division, under Juan Martinez Recalde.

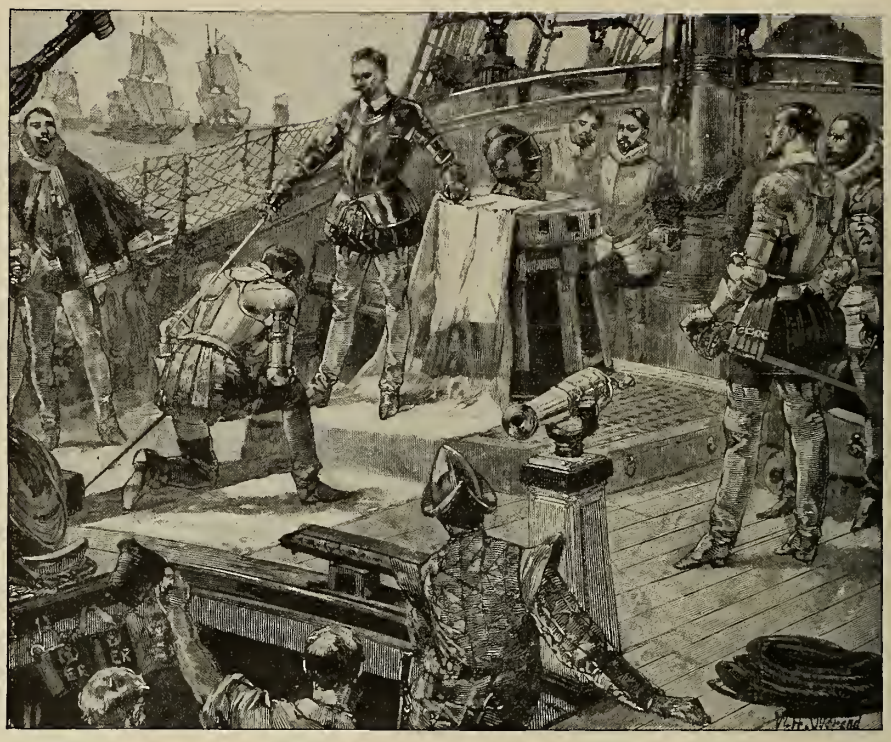
The sight of the "Invincible" Armada had not had that terrible effect which its godfathers promised themselves. The light and nimble English ships sailed to and fro, pouring in their shot with good effect, while the unwieldy galleons of the Armada hauled up to deliver their fire or ran before the wind, if such an operation can be called running which was of necessity very slow. Off Plymouth, where most of the vessels left behind now joined the Lord Admiral, several very smart actions occurred.

Howard, in the *Ark Royal*, gallantly bore down on the *Rata*, a vessel of nearly a thousand tons, flying the banner of Alonzo Da Leyva, which the Admiral probably mistook for Sidonia's. Personally directing the operation from his quarter-deck, Howard took his flagship into action. Sheering almost alongside of the mighty galleon, the English gunners poured a hailstorm of cannon-balls on the decks of the enemy, dealing havoc in the crowded ranks of the Spanish soldiers. Then, springing his luff, the Admiral stood under the stern of his antagonist, raking him fore and aft, fetching the gilding off his quarter badges and sending his spars rattling about his ears. The jeunesse of Spain's bluest blood had thus an

SIR FRANCIS DRAKE.

early opportunity of receiving their baptism of fire, and remarkably hot they found it.

The flag-ship of De Valdes and the *Capitana*, of the Biscayan squadron, were, in their turn, attacked by the



THE LORD ADMIRAL KNIGHTING THE VICTORIOUS CAPTAINS ON BOARD THE 'ARK ROYAL."

Triumph and the *Victory*, and the superior gunnery of the English told at once. De Recalde had shortened sail to await the English attack; he got terribly mauled, every English shot telling in his hull or rigging, whilst those from the Spaniards either flew high or wide of the mark. But the Dons were not given to leaving a commander in the lurch, and to his help came the ship of his vice-admiral, the *San Mateo*, of Don Diego, of Pimental, and the *San Juan*, of the division of San Flores, commanded by Don Diego Enriquez, a son of the Viceroy of the Indies. Now, too, Sidonia furled his sails and lay a-hull, to induce the English to close, and Lord Howard, who intended nothing of the kind, summoned his ships together that he might hold a council of war.

It was arranged at this council that Drake, in the *Revenge*, should act as the leader of the English van-squadron during the night, keeping touch with the rearguard of the Spaniards, while the main body, under Howard, should follow his lantern, and Captain Hawkins bring up the rear. Drake, however, either omitted to hang out his light, or, as appears more probable, seeing a chance for prize-money in what he supposed to be a few stragglers from the enemy drifting towards the French coast, "doused his glim" and stood after the possible plunder.

The result of this dereliction of duty —which Drake seems to have been quite capable of conceiving and carrying out—was very nearly disastrous. The English ships stood on after the only light they saw, and, hugging it, found, when day broke, that the lantern was that of the *San Martino*, and not in the *Revenge* at all. Some of them were perilously near the Spanish fleet. The *Ark Royal*, the *Bear*, and the *Rose* were within culverin-shot of the enemy, while many of their consorts were hull down astern. The Spaniards,

however, had not the promptitude to take advantage of the mistake thus made; and Howard, seeing the situation, hung out a signal to rejoin the flag, and, meantime, shortened sail to allow his scattered ships to close up.

The Dons had not passed an altogether happy Sunday night. During the fight, the *Santa Catalina* had been almost disabled, and towards evening she fell foul of the flag-ship of her division, *Nuestra Senora del Rosario*, and smashed the bowsprit of this vessel. Then, when a little later, Sidonia made all sail, and ordered the fleet to tack, the *Nuestra Senora's* foremast went over the side, bringing down the main-yard with it and completely incapacitating her. Several attempts were made to take her in tow, but the wind and sea were too boisterous, and ultimately Sidonia found that he must leave her behind, with another disabled galleon, and several of the tenders or "pataches" under Don Augustin De Ojeda, to render such assistance as they were able.

The other disabled ship was Oquendo's flag-ship, which had been partially blown up by an explosion of her powder magazine. The upper deck and stern-castle went overboard, and many of her crew perished. Hawkins put a prize crew on board, and this vessel was sent into Weymouth,—curiously enough, in charge of the very Captain Flemming, who, some writers would have us believe, was a pirate.

One of the first affairs on Monday morning was an engagement between the disabled *Nuestra Senora del Rosario* (or, as she was more generally called, the *Capitana*) and the *Ark Royal;* but Howard, after pouring in a broadside and driving off Don Ojeda and his pataches, passed on, seeking more worthy prey than a crippled ship. Frobisher, in the *Triumph*, next tackled her, and some merchant-ships, amongst them the *Margaret and John*, of London; but Frobisher passed by, in accordance with the flag-ship's signal, and there was too much fight left in the wounded Don for the merchantmen to take her by themselves.

FROM PINE'S PLATES OF OLD TAPESTRY HANGINGS IN THE HOUSE OF LORDS.

THE SPANISH DISLODGED BY THE ENGLISH FIRE SHIPS.

About this time Drake came along, disgusted, we may conclude, with the result of his night's work; for his supposed prey had turned out to be Flemish merchant-ships, who had got among the Spaniards by mistake. The disabled galleon was too tempting a prize for the buccaneer leanings of the circumnavigator, and learning who his new assailant was, the Don quickly capitulated, and *Our Lady of the Rosary*

was sent into Torbay. Treasure to the amount of 55,000 ducats, and a great quantity of gunpowder, were found in her; the latter was transhipped to the *Roebuck*, which had towed the prize into port, and dispatched for the use of the fleet. As for Pedro De Valdes, Drake took him on board the *Revenge*, perhaps thinking that the Don's ransom would help to line his pockets.

In consequence of the separation of the ships during the night by the Vice-Admiral's act, Monday was mainly spent by Howard in collecting his squadron and rearranging plans. Sidonia's feelings at this time must have been somewhat less hopeful; the fight of Sunday had been little more than a skirmish, yet two of his flag-ships were in the hands of the despised English, while considerable damage had been done to other of his vessels, and many dollars transferred from one side to the other. Recalde's flag-ship was no longer fit to act as chief of the rearguard, and Da Leyva, in the *Rata*, was now detailed for the duty with two divisions, instead of one, including the galliasses, and, amongst the galleons, the *San Mateo*, the *San Luis*, the *Santiago*, and the *Florence*,—all commanded by brave officers of the Admiral's own squadron.

Tuesday morning, off Portland Bill, the wind had got round to the north and northeast, giving Sidonia the weather-gauge, and an opportunity of offering or refusing battle, as he pleased. Some of the leeward ships of the English were offering what he considered a good opportunity for carrying out his tactics of boarding. He dispatched the rearguard, and especially the galliasses, to attack them. The English ships were those of Frobisher, Lord Thomas Howard, and others of the van.

A smart assault was made upon them, the Spaniards using their oars in an endeavour to get near enough to board. But the seamanship and the gunnery of the men in the *Triumph* and the *Lyon* was too good; they manœuvred their ships with wonderful smartness, and poured in their fire with such capital direction as to sweep the galley slaves from their benches and so prevent the galliasses attaining their object. Had it not been for the handiness of the English craft, the Dons would undoubtedly have succeeded in their purpose. On both sides great valour was exhibited; but the Spanish firing was slow, their aim bad, and their small guns and light arms did nothing like the damage of the heavier English cannon.

The wind veering round to the southward, Sidonia himself was able to take part in the fight, and more English ships joined in the combat. Round the big *Triumph* the battle waged with varying success all the day, as the Spaniards, who imagined they were going to make a prisoner of the gallant Arctic explorer, found they had caught a Tartar instead. Frobisher was, indeed, the hero of this day's fight. Then, when Sidonia had called on his reserves, but without altering the aspect of the fight—and the wind now made it a necessity for him to continue his course up the Channel—the merchantmen, the London ships, the privateers and smugglers came out of every port in every sort of craft that would take the sea and carry a weapon; and from every nook and harbour the seafaring population gathered to prey on the discomfited foe. Truly, as Howard said, he was plucking their feathers, one by one!

Wednesday it was calm; both fleets drifting up-Channel about six miles apart, the Spaniards careening their ships to stop the shotholes; and Howard sending urgent requisitions to the shore for more powder and projectiles.

When day dawned on Thursday, it was still almost calm, with light catspaws stealing over the surface of the water from the direction of the Isle of Wight. Two of the Spanish galleons were astern of the main squadron. These were the *Santa Anna*, a storeship, and a Portuguese galleon. Hawkins boldly attempted to cut them off, and, after some fighting, seems to have forced them to strike; but Da Leyva and Don Enriquez coming with the galliasses to their assistance, the Devonshire man was himself hard pressed. The *Santa Anna*, however, was so

badly damaged that, as soon as she got out of the melee, her captain, Juan Saurez, took her over to the French coast, and there ran her ashore.

The *Ark* and *Lyon* now towed down to the scene of action, and seeing that Sidonia's ship was somewhat separated from the rest, Howard, supported by Southwell, Sheffield, and others, made an attack upon her. The battle waxed hot, and the galleons and galliasses were fain to come to the rescue of their chief, when, as usual, the English played their tactics of drawing off and hammering at a distance.

The *Ark*, however, appears to have been somewhat damaged in collision with a galleon which unshipped her rudder; anyway, she became separated from her friends, and, says a Spanish spectator, "our flag-ship made for her, with most of the ships of the Armada. The enemy's fleet stood to windward, leaving their flag-ship astern, and in such danger that she was towed by eleven launches, striking her standard and firing guns as signals for assistance. Our flag-ship and the other ships were closing her so fast, that the rest of the enemy's fleet began to make a show of coming to her support, and we made certain of being this day able to board them, which was the only means of obtaining any decisive advantage. At this moment the wind freshened in her favour, which increased her distance from us, and she cast off the launches that were towing her; now, too, their fleet, which was falling to leeward of the Armada, recovered its position to windward."

And so all day, from dusk to dark, the fighting went on, the English, with the dogged pertinacity of their race, towing their vessels into action, and, one after another, from the big *Triumph* down to the tiny *Pippin*, hammering away at the hated foe.

Friday, a lovely calm summer morning, Portsmouth in sight, and the fleets drifting along within view of each other. But while on board the one despondency and foreboding were making rapid headway, on the other hopes ran high, and there was no longer a doubt as to the upshot of the adventure. Many of the young Spanish noblemen, having had enough of it—and perhaps luckily for themselves as it turned out—left the fleet, the disillusionment of the invaders had speedily arrived. The Duke was dispatching messages to the Prince of Parma, asking him to send him at least forty small ships to cope with the swift-sailing craft of the English, "the heaviness of our ships and the lightness of theirs rendering it impossible to bring them to close action."

Ever since daylight preparations had been in progress on board the *Ark* for a grand entertainment. Many of the great English nobles joined the fleet this morning, and the highest reward in his possession was to be conferred by the Lord Admiral upon those officers who had so well seconded him during the past week. Friday might be fast day for the Dons, the English would make it a feast. Lord Thomas Howard, Lord Sheffield, and Roger Townsend, with John Hawkins and Martin Frobisher, were to receive the honour of knighthood for their gallant behaviour and glorious deeds of bravery. Knighthood was a dignity given in those days only for distinguished service to the State, and was as much sought after by nobles as commoners. Never had the dignity been better earned than by its recipients on this occasion.

It was decided not to fight again until the enemy had got into the Straits of Dover, but to wait for further supplies of powder and shot and the reinforcement of the squadron under Lord Henry Seymour and Sir William Wynter, and then, "to make an end of it." To those who have read thus far of the doings of the English seamen, it must have become plainly apparent that it would be quite absurd to ascribe the victory of Trafalgar to the weather as those which were won by the naval heroes of 1588. The fights which took place subsequently will only serve to strengthen this view.

Saturday was another fine day, with light airs, and at about 5 P. M. the Armada anchored in Calais Roads. The same evening Howard brought his ships

THE RETREAT OF THE ARMADA.

to an anchor in the Downs and welcomed Seymour and Wynter with the "Squadron of the Narrow Seas." By this, the English fighting strength was brought up to close on fifty heavy ships, while the demoralised Spaniards could scarcely muster ten more at the most. Sidonia and Parma, too, had at last got into correspondence, for a messenger came from the latter to say he was glad the Armada had at length arrived, but he did not hold out any prospect of being able to do much himself. Nor is it easy to see how he could while the English had command of the sea, and there was yet no signs of their having lost it. As it is now, so it was then; the invasion of the country, thanks to the silver streak, is an impossibility so long as England maintains a sufficient force in the Channel to beat the enemy.

In the English fleet on Sunday morning, at the council of war, it was decided to employ fire-ships for the enemy's discomfiture. So the barque *Talbot* and others were filled with combustibles, and made ready for the business. We may picture to some extent the situation from the accounts of the spectators. A dark and gloomy night, with the tide running up-Channel; despair already the prevailing feeling in the Spanish fleet; most of the soldiers tired out with the fighting of the previous week; the mariners, whose proportions were less and whose business exposed them more, nearly all killed or wounded; those who were well trying to get a good night's rest while at anchor, to prepare themselves for the arduous work they knew lay before them.

Suddenly the alarm was given, and, as they ran on deck and gazed out over the bulwarks towards the foe, there, coming down on the wind, were the flaming ships, with helms lashed, trains fired, tongues of fire darting from the rigging and flaring away from sail and spar, every now and again explosions taking place; the prospect to the Spanish soldiers must have been terrible. It is not to be wondered at that confusion and panic reigned in the disheartened squadrons. Some of the ships were burnt, some came into collision, smashing spars and bulwarks; others drifted down towards the shoals of Dunkirk, and the big *Capitana* of the galleons, heading for the harbour of Calais, drove upon the bar. Though the great bulk

of the fighting ships rallied at daylight to the flag, the Armada was never again in position to act concertedly.

But now on Monday, July 29, the Duke of Medina Sidonia, gathering round him the remnants of his Armada, prepared for the final fight. The wind was blowing strong from the northwest, right over on to the Flemish shoals, and any disabled vessel was almost bound to go on shore. So he formed his ships up in a half moon, of which the horns were away towards the North sea, and, still struggling to windward with port tacks aboard, beat to quarters, resolved, if he could not win, yet to die like a gallant nobleman of Spain.

Down came the Englishmen with wind and tide in their favour, no longer keeping at a distance, but coming within "shot of arquebuse," and pouring in their fire at close quarters as they broke through and through the Spanish line. Howard and Hawkins, Sheffield and Cumberland drove in the centre, whilst Drake and Frobisher crushed the southern, and Seymour and Wynter the northern horn of the crescent. Till 3 P. M. the battle raged; the Spaniards were terribly beaten, Philip's power was shattered, and the foundation of Britain's naval empire firmly established.

How many of the Spaniard's ships were destroyed in this day's fight is unknown. The Lord Admiral says three were sunk and four or five driven ashore; the Spanish account points out that the ships of Don Francisco de Toledo, Don Deigo Pimental, and Don Deigo Enriques "were now quite disabled and unserviceable, with most of their crews killed or wounded." The *San Felipe* and *San Mateo* went ashore on the Netherlands coast, and the *San Juan de Sicilia* sank in sight of an English man-of-war, just as she was about to become a prize. As for the great galliass on the bar at Calais, she was taken by the small boats of the *Ark*, the *Margaret and John*, and other ships, her captain, Don Hugo De Moncada, losing his life in a vain attempt to resist the boarders, led by one Richard Tomson, of Ramsgate. The English plundered her, but the hulk fell a prize to the Governor of Calais.

Tuesday, July 30, the English were in hot pursuit, and at early dawn came up with the shattered remnant of the Armada. The *San Martin*, Sidonia's flag-ship, had many shot-holes between wind and water, and nearly all the galleons he could rely on were in still worse plight. The pilots told the Duke it was impossible, if the northwest wind continued, to prevent the whole of the Armada going upon the shoals off the coast of Zealand, and, says the Spanish writer, "the English, seeing that the Armada was on the point of being wrecked, refrained from attack."

As a matter of fact, we know that it was want of powder and shot which prevented them making the most of their victory. However, when the Spaniards had got into 6½ fathoms, "it pleased God to change the wind to W. S. W.,"

AN OLD ANCHOR IN WHITEHALL YARD, BELONGING TO A SHIP OF THE SPANISH ARMADA.

and the Dons clawed off without losing a ship. Then the Duke called upon his officers for advice as to what should be done, and all the members of the council agreed that "the Armada ought to put back into the Channel if the weather allowed of its doing so, but if not, that, yielding to the weather, they should return by the North Sea to Spain." With this sop to their consciences they stood away to the northward, and the English left them to the care of the elements.

The "Invincible" Armada came, saw, and fled, the remainder of the story of the ill-fated expedition being

merely a record of the difficulties, dangers, and disasters which befel the remnant in attempting to clear the Scotch and Irish coasts on their journey home to Spain. Thomas Fenner, who followed them so far as the Firth of Forth, and left them on August 4, with a couple of pinnaces to keep an eye on their future movements, records their utter demoralisation. The gale increased, none stopped to succour a comrade, many foundered in the North Sea or were wrecked on the Scotch coast, more came to grief on the rocks of Ireland, and of the vessels which left the Tagus, barely half returned. Of the 30,000 men who sailed in the Armada scarce one-third got back home again; those that the bullets of the English did not reach, fell victims to the winds and waves, the rocks and the shoals, hunger and thirst, or the savages of Ireland.

This was a sufficiently tragical termination to the expedition which, less than a twelvemonth before, had menaced the country so terribly. Never since has the English nation been exposed to a danger seemingly so imminent and so overwhelming. The lessons of the occurrences sank deep into the hearts of the people of that time. Their importance is not lessened by the three centuries that have passed. The defeat of the Armada taught friend and foe alike that Britain's shores are inviolate so long as Britain's fleet is efficient.

The peril was undoubtedly increased by the procrastinating imprudence and vacillating policy of the authorities. It is a sufficient commentary on the state of affairs on shore that the preparations for the protection of the Thames were not even completed at the date of the fight off Gravelines. At the time that Queen Elizabeth was reviewing her troops at Tilbury, the Armada was a scattered and defeated host. It was no mere chance, too, as Professor Laughton points out, that made our ships more handy, more weatherly, and more heavily armed than those of the enemy. These advantages were due to the foresight and enterprise of the English naval commanders, and not to them was the shame that these memorable battles were fought and the discomfiture of the enemy assured by seamen whose wages were unpaid, who were half-starved, and lamentably ill-supplied with the munitions of war.

Well might the Queen in state attend a public thanksgiving at St. Paul's; well might prayer and praise go up in gratitude for the Divine mercy. England had been true to herself, and no difference of religion or of politics had been to weaken the national unity. To the safe keeping of her sons had been confided the integrity of the island, and, under Divine Providence, they had nobly sustained the trust reposed in them. We may well take the advice which Thomas Delany, in a contemporary ballad, gave his countrymen:—

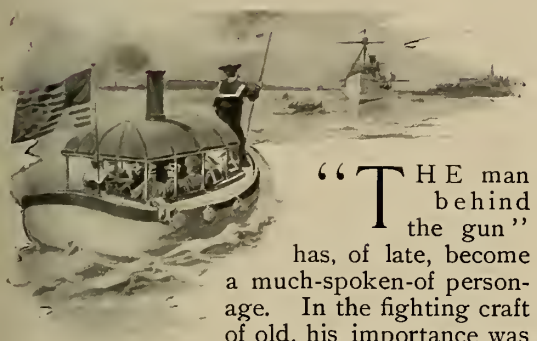
O noble England
  Fall doune upon thy knee
And praise thy God with thankful hart
  Which still maintaineth thee
And you deare bretheren
  Which beareth armes this day,
For safeguarde of your native soile,
  Marke well what I shall say.
Regard your duties faithfullie,
  Thinke on youre countrie's good
And feare not in defense thereof
  To spend youre dearest bloud.

The old anchor, represented in one of the smaller engravings, lies, with several other naval trophies, outside the building of the Royal United Service Institution, in Whitehall Yard. It was found on the coast of Donegal, where, and on the coasts of the Bay of Sligo, of Mayo, Galway, Clare, and Kerry, many of the ships of the Spanish Armada were wrecked on their way homeward from the North Atlantic. This anchor was presented by Admiral Ommaney, R. N., to the United Service Institution.

SOME PRACTICAL NOTES ON AMERICAN BATTLESHIPS.

As Seen by "The Man Behind the Gun."

By Lieutenant E. W. Eberle, U. S. N.



"THE man behind the gun" has, of late, become a much-spoken-of personage. In the fighting craft of old, his importance was never in question, and in the modern battleship, too, despite its largely automatic make-up, his place is filled with responsibilities, and his characteristics are those which help in great measure, to decide the battle. His opinions of the modern floating fighting machine deserve a hearing, therefore, and the following notes, presented by Lieutenant Eberle a short time ago before the United States Naval Institute, are worthy of careful study.—The Editor.

American battleships of the *Oregon* class were designed, built and given their trials on a theoretical draft of twenty-four feet; a draft which has no practical significance and upon which they have never gone to sea since being commissioned. With her coal, stores and peace-time supply of ammunition on board, and ready for a cruise, the *Oregon* has a draft of more than twenty-six feet, displacing more than 11,500 tons, and her armour belt is very little above water. Thus when ready for sea, with the main armour belt submerged, these battleships are very little better off in the way of above-water protection than armoured cruisers, their only protection above-water being the four-inch armour belt.

Granting that these ships could go into action with very little coal in the bunkers, so as to get the full benefit of the armour belt, and in comparatively smooth water, even then a few shot holes at the water line forward and abaft the armour belt would soon fill enough water-tight compartments to cause the ship either to turn over or to heel to such an alarming extent as to interfere with the working of the guns and to submerge the armour belt completely.

As the all-important object is to keep the ship on an even keel so as to fight the guns most effectively, it would seem far better to allow the ship to settle steadily in the water until the main armour belt is entirely submerged, rather than to have her heel to an alarming extent; and for this reason, in these ships, I think that all unprotected water-tight compartments at the water line, forward and abaft the armour, should extend the entire width of the ship in order to prevent the ship "heeling" when they are caused to fill through shot holes. It requires about forty tons to increase the draft one inch in these ships when at their normal displacement, and consequently it would not take a very large compartment of water to completely submerge the armour belt when on an even keel, and thus the battleship is again reduced to the level of an armoured cruiser, even when she started out with very little coal in her bunkers.

For these reasons I am decidedly op-

posed to the dangerous theory of partial armour belts, which leave both ends of a ship entirely unprotected; and, as I said before, a few shot holes at the water line of these unarmoured ends would soon admit sufficient water to put the main armour so far below water as to be of no use; and a few more shot through the four-inch armour, which would now be the only water-line protection, would soon admit enough water above the armoured deck to cause the ship to turn over or to put the heavy guns out of action by the angle of heel. In my opinion, it would be much better to have a lighter and wider armour belt extending from stem to stern than a partial armour belt of great thickness.

Spare Articles.

The argument always advanced against a complete armour belt is that these ships, on their present displacement, cannot carry the weight at that height; but why not dispense with various weights that we now find on board battleships and which have nothing to do with the fighting qualities of the vessels? The ships are entirely too complicated and have too many encumbrances for fighting machines.

Walk through a battleship when she is cleared for action and note the hundreds of articles that are struck below on account of not being a part of the fighting outfit, and see the many things marked "overboard" on account of belonging to the peace equipment! These are the articles that complicate and encumber battleships and take the place of weight that should be given to armour for the unprotected ends of the ship. It is impossible to obtain the most efficient results if we design a fighting ship with the idea of fitting her with both a peace equipment and a war equipment; and I firmly believe that every battleship should be always kept in fighting trim—even to the colour of the paint—and that all superfluous articles should be sent on shore.

Stores and Equipment.

I cannot see why battleships should be supplied with everything in the way of stores and equipment that are supplied to cruisers when fitting out for a three years' foreign cruise. Our battleships are principally for home defense and their radius of cruising is limited by our coaling stations; therefore, why not limit their outfit of stores and supplies to a certain extent—say, six or eight months—and thus do away with the great weight due to over-abundance of stores, which weight should be given to more ammunition and to armour for the unarmoured ends.

There is no reasonable argument for filling the store-rooms of battleships with from two to three years' stores when their coal capacity limits them to twenty-four days' steaming at the outside. Each one of the vessels is burdened with enough spare articles and enough needless stores to fit out another ship of the same class in time of war.

If, in war times, our battleships are to remain on our own coast on the defensive, then they are at the very base of supplies, and they can be kept filled up with coal and stores; if they are sent to the enemy's coast to act on the offensive, they must necessarily be accompanied by coal-laden steamers; so why not at the same time have them accompanied by supply ships? Every fleet of heavy ships should have its fast colliers and supply steamers, and then battleships could dispense with the present plan of carrying large quantities of stores and spare articles, the weight of which tends to sacrifice an ample ammunition supply and prevent more side armour.

Torpedoes.

Next, let us gain weight by doing away with torpedoes in battleships, for are they not entirely out of place in battleships, in armoured cruisers, and in large vessels designed as scouts? I cannot imagine any circumstance under which a battleship would dare to use her torpedoes, unless it would be to give the "knock-out blow" to an already defeated and disabled enemy before he could lower his colours; and it would seem poor judgment to approach within torpedo range of an enemy that is already whipped, because he might pos-

sibly have an uninjured torpedo tube and that would put both vessels upon an equal footing again, thus possibly throwing away the victory that previously had been won.

Cruisers will use their high speed to avoid engagements with battleships, and therefore battleships will in most cases be opposed by battleships or armoured cruisers. In such engagements the battleships would probably never be within torpedo range of each other, and if by chance they should close to 800 yards, would any commander dare open his broadside torpedo ports and attach the war-head in the face of the terrific fire of his opponent's numerous rapid-fire guns?

A better target for rapid-fire guns at 800 yards than an open torpedo port in the armoured side of a battleship could hardly be desired; and if the "men behind the guns" fail to explode the air-flask or war-head, they would most certainly destroy the tube itself. The *Oregon* has a bow tube, a stern tube, two starboard broadside tubes, and one port broadside tube—all above water. Her bow and stern tubes are fixed, and as they are not protected by armour, they may as well be eliminated from the discussion. The broadside training tubes are behind four inches of armour, which offers little protection against the main battery of a battleship. Besides, the broadside tubes could not be opened except in smooth water; the bow tube could never be used when under way, excepting at very slow speed, a speed at which the *Oregon's* helm is of so little use that she must be handled with her engines.

It is claimed from experiment that war-heads will not explode when struck by rapid-fire shells unless the small detonator itself is struck; but would any commander of a battleship be willing to stake the fate of his ship in battle upon this assumption, merely for the sake of obtaining a chance shot at the enemy, provided his tube and air flask have not already been penetrated? I do not believe that any commander would so menace his own ship, when in action, as to open his torpedo ports and attach the war-heads as long as he could fight a single gun. If every gun has been silenced and the enemy should be so indiscreet as to approach within short range, then a torpedo might possibly prove successful against him; but when a ship has been so seriously battered as to have every gun disabled it is hardly possible that her torpedo tubes remain uninjured behind only four inches of armour, not to mention what would occur when the torpedo ports are opened and the tubes exposed to fire.

In my humble opinion, torpedoes in battleships, in armoured cruisers, and in scouts, are out of place and are a menace to the ship that carries them; and I believe that in the near future our policy will be:—Torpedoes in torpedo vessels and in nothing else. However, if we must have torpedo tubes in battleships, let them be submerged. I consider that the appropriation for each battleship or armoured cruiser should contain a provision for two torpedo-boat destroyers. These two "destroyers" should attend the battleship during all manœuvres, and in time of hostilities they should serve as her "faithful watchdogs" at night, being always on the alert for torpedo-boats and rams. The service that these "destroyers" could render a fleet of fighting ships would prove most valuable, some on the scout and others on the lookout. They could form an inner picket line for the fleet, the outer line being formed by the large cruising scouts.

How much more secure and comfortable the fighting ships would feel, when on the blockade or when approaching the enemy's coast, if each had two effective torpedo-boat destroyers to insure protection from the ever-dreaded little "night prowling" torpedo-boats. The two "destroyers" should be a "part and parcel" of the battleship and under the orders of her commanding officer; and they should look to the "mother ship" for all supplies when cruising and also for protection from the enemy's fighting ships. During action they could possibly find shelter under the unengaged side of their powerful protector and be ever ready to dart

forth to repel the onslaught of torpedo-boats. Thus, for protection against the enemy's torpedo-boats, the fleet should rely upon its own "destroyers" and not upon useless torpedo-nets.

Boats.

Why should a battleship be burdened with fourteen boats? Why not do away with some of these weights which are carried so high? Then we could also dispense with two of the four heavy boat cranes of the *Alabama* class, for every pound at that height counts.

From the fact that ships continue to carry large numbers of boats in cradles on the upper deck beams, it would seem that little apprehension is felt for the fierce blaze that these boats would make if set on fire by a bursting shell. In our battleships the boats are carried on the beams at the height of the bridge deck, and some are stowed in nests of three; thus they would make a superb target for rapid-fire guns and would probably be set on fire within the first ten minutes of an engagement. If shell should penetrate either smoke-pipe below the height of the boats, the heat coming through the shot holes would also assist in setting the boats on fire.

Consider for one moment the serious effect of a fire among the boats during an engagement! Even should the lines of hose that are fitted on the upper deck remain intact, it would be next to impossible to subdue the flames in the face of the enemy's rapid-fire battery; and the heat would very soon drive the crews of the secondary battery from their guns and the captain from the conning tower. The fire, once started, would take all the boats and would find more fuel in the pilot house, the bridge deck and hammocks, so that it would become a rather serious matter.

Such a fire would deprive the ship of her secondary battery, and, as no man could live in the conning tower when surrounded by such a blaze, it would deprive the ship of every means on deck of manœuvring,—a most appalling situation during an engagement. Possibly the enemy may be practically defeated, when suddenly he sees all our upper works in flames and is given encouragement to continue the fight with renewed vigour, possibly turning defeat into victory.

I consider this a subject for very serious thought in connection with our battleships in commission and those building, and it seems to me that the remedy can be easily applied. In the first place we should change from wooden to metallic boats, except possibly the two lifeboats carried at davits; and in the second place our boats should be reduced in number. We still cling to the ancient idea that a ship's boats must be able to carry all the crew in case of abandoning ship—an impossible proposition in a seaway if a week's water and provisions are to be carried. An attempt to use the unwieldy boat cranes for hoisting our boats in a seaway would certainly prove as unsuccessful as the innocent proposition of a landsman, who recently visited this ship, was amusing. The landsman asked why the ship carried so many boats, and he was told that they were required to be able to carry all the men in the event of abandoning ship. He then asked how we would get the boats in the water, and he was answered that they were supposed to be hoisted out at sea by the cranes, but that the success of the undertaking would be in doubt. Our landsman thought for a moment, and then his face brightened as he conceived a brilliant nautical idea, and he said:—

"If the ship is sinking, why not leave the boats in their cradles and put the men in them, then get the oars ready, and when the ship goes down and the boats float, pull away like thunder!"

I fear that an attempt to get the boats out at sea with our boat cranes would come near meeting with the same fate as the "hayseed" proposition of our innocent landsman. We must give up the idea of having to abandon ship at sea, for it would be impossible to hoist out the boats without smashing them to pieces; but if successfully launched and filled with the men and the provisions that they are required to carry, they could not live in even a moderate sea. We must look at this matter in a cold

practical way and decide to stand by the ship, and survive or perish with her, for that is the plain common sense of it. Boats are of very little use at sea to a modern ship, except to rescue a man overboard.

In our present age of high-powered twin-screw steamers we have eliminated the anxiety of being "knocked down" or "driven on a lee shore," which were the most frequent misfortunes that compelled the crews of the old-time sailing vessels to take to their boats and "abandon ship." Necessity for abandoning ship at sea at the present day could only be brought about by very severe weather or by a collision. In the former case—a very improbable one for a well-built steam vessel—the few davit boats of a man-of-war might possibly get clear of the ship with a few men, but the large boats in the cradles could never be hoisted out during a gale that would imperil the ship, consequently the majority of the crew must stand by the ship and trust to her seaworthiness.

In the case of a collision at sea between modern ships their safety would depend upon the rapidity of closing the water-tight compartments, and therefore the crew would have to trust their lives to the good condition and successful working of the water-tight doors. If a collision is so severe that the water-tight compartments of a modern ship will not keep her afloat, then there will be no time for getting out and provisioning boats. In case a ship is stranded a few boats will do the work of rescue and of getting a line through the surf. In time of war there must be no such thing known to a man-o'-warsman as "abandoning ship;" he must make up his mind to stake his fate with his ship and either cheer her colours in victory or go down with her in defeat.

A battleship's outfit of boats should consist of two large steam cutters capable of carrying sixty men each, two large launches capable of carrying seventy-five men each, two life-boats and two dinghies; the steam cutters to be used for all running and towing purposes, and with the launches to be used for carrying stores or landing an armed force.

Armament.

The most important subjects in battleships are the armament, armour and ammunition supply: and all else, excepting the engineering department, must be sacrificed for these three main fighting qualities.

When the United States government commenced building a navy the policy was to have her ships armed with more guns and with guns of greater range than were carried by the war vessels of other nations. That policy was carried out in our early wars, and history records splendid victories, and these victories were made possible by the large number of long-range guns carried by our ships.

Up to the time of designing the battleships that are now on the stocks, our uninterrupted policy had been to build ships that excelled in battery all foreign ships of the same class, and the *Oregon* class maintained this policy, as their eight-inch guns far outclass the six-inch guns of foreign battleships. The *Kearsarge* and *Kentucky* are somewhat doubtful about maintaining our cherished policy, as many look upon their superimposed turrets with a skeptical eye. However, in our latest battleships we have completely abandoned the policy that we had held to for a century, as these ships are designed to be the equals of foreign battleships in armament, gun for gun, and not superior to them.

We have abandoned the splendid eight-inch guns which made the *Oregon* class superior in armament to any ship afloat, and now we have nothing but six-inch guns to back up the thirteen-inch. I think this is a very unwise departure from the policy that always brought us victory in our past wars; and should the *Alabama* class engage with ships of the same class I fear that the victory would hang in the balance, while it would be insured had our ships been given the eight-inch guns.

I consider the forty calibre eight-inch gun a superb piece of ordnance, and one

that we can ill afford to dispense with in our battleships, although I do not commend the eight-inch turret mounts in the *Oregon* class. Those turrets simply invite disaster, as they are perched high in the air, with only a four-inch armoured ammunition tube underneath them for protection. These turrets make an excellent target, and one five-inch shell striking and exploding in the armoured tube under the barbette would throw the turret and its two eight-inch guns out of action.

Why not mount a single eight-inch gun *en barbette* on the main deck at each angle of the superstructure, the barbette being twelve inches thick and carried down to connect with the main armour belt, thus insuring absolute protection for the ammunition, and eliminating the chance of having the eight-inch turret "struck beneath the belt" and being "knocked out?" I would also mount an eight-inch gun *en barbette* on the main deck amidships. This plan would give three eight-inch guns on a broadside with splendid protection, and the weight of the armoured barbettes would not exceed the weight of the present turrets.

These guns should be worked entirely by hand gearing, and I believe that these three guns on a broadside could deliver more shots within a specified time than the present four guns mounted in two turrets. I would mount two six-inch R. F. guns on the broadside between the eight-inch barbettes, one in each diagonal of the superstructure, well inboard, two on the upper deck amidships, and two under the forecastle —thus having eight six-inch guns in a broadside. Of course, the six-inch guns in the diagonals would have a very limited arc of fire. I would have the upper deck fairly bristling with twelve-pounders and six-pounders.

The present plan in the British ships of enclosing each six-inch gun by a thick Harveyed steel casemate is an excellent idea. It guards against a raking fire and at the same time it shuts off each gun from the view of its neighbour. This causes each gun's crew to be independent and prevents its demoralisation upon seeing the crew of an adjacent gun swept away by a bursting shell.

The eight-inch guns of the *Oregon* class cannot be fired in a fore and aft line without endangering the officer in the hood of the thirteen-inch turret, but if they were mounted on the main deck there would be no danger from a fore and aft fire.

It appears that the tendency in the British Navy, and I regret to say in our navy, is to reduce the number of guns and to increase their arcs of fire; and also to have no guns above six-inch calibre for supporting the twelve or thirteen-inch. This method of decreasing the number and calibre of guns is an ideal theory for reducing weights; but ships are built to carry guns and to fight, and it would seem better to reduce weights elsewhere than in the battery and ammunition.

A comparatively small number of guns are thus placed on board our new battleships, and each gun commands a large arc of fire; but the theorist does not consider the fact that one shot may disable a gun, and then a large arc is without a gun to cover it. I believe in a large number of guns with reduced arcs of fire, for then you will have more guns, in proportion, at all stages of the battle; and, if necessary, the ship can be manœuvred to bring the last guns to bear. If every gun in the ship's armament is to have an extensive arc of fire then it is impossible to carry many guns, and when these few are disabled the ship is defeated.

I do not see how a battleship can have too many guns, even if they are placed side by side; and to me it seems a sin to build a great battleship of 12,000 tons like the *Alabama* and give her a main battery of only four thirteen-inch and fourteen six-inch rifles. To my mind she should have a main battery of four 12-inch B. L. rifles mounted in turrets at least twenty-five feet above the water; six 8-inch B. L. rifles mounted singly in barbettes on the broadside (as described above) at least eighteen feet above the water; and sixteen 6-inch R. F. guns mounted in armoured casemates on the broadside.

The British *Majestic* class should be able to carry, on their 15,000 tons displacement, at least six 8-inch B. L. rifles and several more 6-inch R. F. guns than they have at present; but those ships have a superb secondary battery in their sixteen 12-pdr. (3-inch) Q. F. guns and twelve 3-pdr. Q. F. guns. However, I prefer a smaller number of 6-pdr. Q. F. to the 3-pdr., but the 12-pdr. Q. F. are excellent guns.

Consider what a terrific broadside fire could be maintained by a main battery of four twelve-inch guns supported by the eight-inch and six-inch! I think that twelve-inch guns should be the heaviest guns mounted on board ship, and I believe they will do more execution than the thirteen-inch, on account of their greater rapidity of fire.

In the present age when heavy fighting ships cruise in fleets, naval engagements between single ships will be rare; consequently during battle each ship of a fleet will have no trouble in finding enough of the enemy's ships to serve as targets for all the guns of her battery, and there need be no fear of some guns not bearing on the enemy's vessels. Therefore I claim that the ship that mounts a large number of guns with small arcs of fire will be superior to the ship with fewer guns and large arcs of fire. The former vessel will be able to deliver many more pounds of metal against the enemy's various ships; and contests between fleets of battleships will be decided by the weight of shell thrown by guns of six-inch calibre and above. Consequently, when we abandon the eight-inch guns in our new battleships we surrender the great advantage that we have always maintained over foreign ships, and we reduce our armament to the same plane as theirs. We should endeavour to retain the eight-inch guns in the broadside, because, as in the past, the naval engagements of the future will be fought with broadside fire and not with a fore-and-aft fire.

In an engagement between battleships of similar armour and displacement, which one will probably be the victor? There can be but one answer. It will be the one that effectively delivers the greatest amount of steel against the other ship. During the engagement each ship will necessarily lose the use of numerous guns and men, and therefore the ship that carries the larger number of guns and that has a reserve force of men below in protected places for filling the vacancies at the remaining guns, will certainly have the advantage; and some obscure guns that are generally looked upon with disfavour on account of their small arcs of fire may, at the critical moment when their companions of large arcs are dismounted, become the means of insuring victory. Give us guns galore, for the time will come when each gun will give a good account of itself, and our terrific broadsides will bring us victories as they have in the past.

Complement.

American battleships have not enough officers and men to fight the guns efficiently, to supply ammunition rapidly, and to form a reserve force for filling vacancies.

In naval warfare between first-class powers, the one that can fight the greatest number of guns and men throughout the action will be victorious; and therefore the first consideration should be given to supplying ships with large crews and with as many guns as can be carried. Consideration should also be given to protecting the men and the guns by armour in order to retain their services as long as possible. In battle the prime object is to kill as many men as possible, thus silencing the enemy's guns by depriving them of their crews. No matter how riddled and battered a ship may become, as long as she floats and guns remain intact the men will fight desperately; so it follows that the men must be killed, the guns dismounted, or the ship sunk in order to insure victory, and the easiest plan is to kill.

When battleships of the *Oregon* type engage other battleships it would be simply slaughter to keep the crews of the six-inch and 6-pdr. guns at their

exposed stations when at long range, and I believe that a wise commander would send the crews of these unprotected guns to seek shelter below behind armour, and thus have them ready to fill vacancies in the crews of the heavy turret guns and to man their own guns when at close, effective range.

If the 6-pdr. crews are kept at their guns from the beginning of an engagement, I fear that none of them will be alive to fight their guns when they become of use at short range. If the opposing battleships have their heavy guns mounted *en barbette* and not in covered turrets, or when engaging cruisers with their exposed gun crews, then it would be necessary to fight the six-inch and 6-pdr. guns when within moderate range; but otherwise it would be folly to allow those gun crews to remain at their exposed stations as a target for the enemy's heavy guns at long range. Heavy guns behind thick armour are the ones that must be depended upon to do the fighting at long range, and the crews of the smaller guns must be sent below for shelter. Preservation of the fighting men is bound to be the all-important rule of the successful commander.

The Battleship at Sea.

The word battleship should imply that the ship is able to give battle to any vessel afloat, no matter where or when encountered. Do our present battleships fulfil this requirement during moderately bad weather at sea? Only once during her commission has the *Oregon* put to sea without encountering a moderate or a severe gale, accompanied by rough to heavy seas. During none of these gales could she have fought the guns of her main battery, except possibly her eight-inch guns at intervals, nor could she have fought her thirteen-inch guns until hours after the gale had "blown itself out." If it were possible to control and point the thirteen-inch guns with the ship rolling from eighteen to twenty-nine degrees, would it be wise to take off the port bucklers and run out the guns when the main deck and turrets are being swept by seas at every roll? Under such conditions it would take a very few minutes to flood the turret chamber and also the shell-rooms and magazines surrounding it.

When a vessel of the *Oregon* type is in a moderate gale, rolling from fifteen to twenty-five degrees, with her main deck awash, an armoured cruiser of the *Brooklyn* class could come along and "knock seven bells" out of her. The battleship could not get away, she could not use her heavy guns, and thus she would be at the mercy of the large cruiser, which, having greater freeboard and more steadiness, could use her guns in all kinds of weather, and with her higher speed she could manœuvre to select her range and her time for placing shell beneath the battleship's armour belt as it comes out of water with each roll.

For the reason that our low freeboard battleships cannot fight their heavy guns when at sea in bad weather, I believe that a fleet of ships of the *Oregon* type, in time of war, should be accompanied by several armoured cruisers like the *Brooklyn;* or a battleship, cruising singly, by one armoured cruiser; this for defensive purposes during severe weather. Therefore, to accompany our present battleships we should have more armoured cruisers, cruisers that can fight under all conditions of weather; and the freeboard of our future battleships should be such as to enable them to keep the sea and fight their guns during the freshest gales. In smooth water our battleships are superior to any ships afloat, both in battery and in manœuvring qualities; but in severe weather at sea, the new high freeboard 14,900-ton battleships of the British Navy will outclass them. The battleships of the *Oregon* class were originally designated "coast-line battleships," but the wind and seas along our coast are about as severe as anywhere else, and therefore such ships should be able to use their guns under all conditions of weather.

One must, necessarily, admire the new British battleships of 14,900 tons, in which, on 3000 tons more displace-

ment than our ships, they have a high freeboard, sea-fighting battleship with a "very large area of side protection," and with a hull of sufficient strength to prevent all fear of docking. It seems too bad that the *Majestic* class have not a narrow armour belt continuing to the bow and stern, for then their fore-and-aft belt and their side protection would make them very undesirable as an enemy.

Let us hope that American battleships of the future will have complete armour protection, that they will have a few feet more freeboard, that the armour belt will be in the right place when in war-time cruising trim, that they will not be burdened with so many boats and other peace-time encumbrances, that the twelve-inch or thirteen-inch guns will be mounted higher and be supported by eight-inch guns *en barbette*, that the rapid-fire battery will be increased, and that reserve forces of men and officers will be assigned to each ship, for then we shall possess ships which we can truly call battleships, as they will be able to stand up and give battle to anything that sails the seas, under all conditions of wind and wave.

In time of war the officers of the ship, and not her designer or builder, are the ones to be held strictly accountable for the fighting condition of the ship and for the result of battle, and it will be too late then to attempt to excuse defeat by attributing it to errors in the design, in the armament, in the ammunition supply, or in the practical equipment of the ship. Therefore I believe that healthy criticisms and practical suggestions by the sea-going officers who man the battleships and fight the guns should be very acceptable to those in authority who create our naval policy; and also to those who are intrusted with the noble work of designing and constructing our great national defenders and who have not the opportunity of observing the practical behaviour of these ships at sea.

VICE-ADMIRAL P. H. COLOMB, R. N.

A Biographical Sketch.

THERE is probably no more striking character connected with the British Navy at the present time than Vice-Admiral Colomb, whose expressed conviction not long ago that huge, heavily armoured warships will soon be things of the past,—their usefulness destroyed by comparatively large sea-going torpedo vessels,—brought him into prominence before naval circles everywhere.

He was born in Galloway in 1831, and went to sea first in 1846, serving in H. M. S. *Tartarus* on the home station; H. M. S. *Sidon* on the Lisbon and Mediterranean stations; and in the *Reynard*, the first screw vessel that ever appeared in Chinese waters. The *Reynard* was wrecked in 1851, and young Colomb was transferred to the *Serpent*, in which ship he was engaged at the capture of Rangoon and in the early stages of the Burmese war.

After passing his examinations at home, he joined the *Phœnix*, in 1854, bound for the Arctic regions to relieve Sir Edward Belcher and the crews of his squadron. They returned in the *Phœnix*, *Talbot*, and *North Star*. Mr. Colomb's next appointment was as mate to the *Ajax*, and then, early in 1855, as lieutenant to the *Hastings*, in which ship he served in the Baltic campaign

of that year. After the peace he joined the *Royal George*, and brought home two regiments from the Crimea. Then he qualified as gunnery lieutenant, but in 1857 was appointed flag lieutenant to Rear Admiral Sir Thomas Pasley, Bart., superintendent of Devonport Dockyard. He had not been long in this office when the Admiralty bought a system of signals called "Redl's Cone Signals," after their inventor, an Austrian officer, and they desired Mr. Colomb to examine and report upon it with the view of introducing it into the British Navy.

As it stood, the apparatus could not be worked in practice, though the theory was most ingenious. Mr. Colomb remodelled the apparatus in various forms for the Admiralty, and, by request of Sir John Burgoyne, for the army. He was appointed to the Channel fleet to carry out experiments with his new apparatus; but it was found impracticable, and the system fell to the ground for the navy. He was more successful for the army, and with his special apparatus the system became, for a time, the army system of signals.

But long before this, Mr. Colomb had become convinced that the "Redl system," however ingenious, did not really supply the wants of either army or navy, and he attacked the whole question of signals *ab initio*, the result being the production, in 1861, of what he called the "Flashing system," which was based, first on Morse's electric telegraph system, and secondly on the principle of revolving lights in lighthouses. It was a system of long and short flashes of light; long and short appearances of any visible object; long and short sounds; all with proper intervals of time between them.

The system thus became uniform for daylight, darkness, and fog; and was first introduced with an extremely simple notation. As luck would have it, the Admiralty at once took a violent prejudice against the new system, and it was nine years before it was fully introduced. It has never been shaken, though it is now generally called the "Morse system," because, in 1866, on Captain Colomb's initiative, the full telegraphic alphabet was substituted for the simpler notation that was originally necessary.

In 1865 the system of tactics in the navy was practically the same as that in use at Trafalgar; it was dangerous and insufficient. The Admiralty had employed several officers to remedy the defect, but from one cause or another none of the plans could be adopted. In that year Commander Colomb undertook the task, and ultimately produced a system which was at once accepted by the service and remains intact at this date, though largely developed.

In 1867 Commander Colomb was attached to the Royal Engineers at Chatham with Captain, afterwards Sir Francis, Bolton, for the establishment of the "Flashing system" of signals in the army. From 1868 to 1870 he commanded the *Dryad* in the East Indies, suppressing the slave trade. In 1870 he returned to England, and was soon after requested by the Admiralty to devise a new system of lighting the interiors of Her Majesty's ships, the existing one being very unsatisfactory and most expensive. He succeeded in producing a system which was at once adopted, was found to effect considerable economy, and remains still the alternative system in place of the electric light.

All questions relating to signals and tactics had been referred to Captain Colomb since 1865, much development being required, and the matter had come so much to a head in 1873 that he prepared a "Manual of Naval Evolutions" for issue to the fleet, in which all the pros and cons of proper and improper developments were discussed, and arrangements made for testing by experiment all such advances as it then seemed desirable to adopt. The book was issued to the service; but Captain Colomb, in inventing the new system of lighting, and revising the tactical system at the same time, overtaxed his strength and left himself prostrate as an invalid for several months.

When completing,—in association with Commander, now Vice-Admiral, H. W. Brent—at the Admiralty in 1866, the final edition of his signal and tactical

books for issue to the fleet, Commander Colomb found that there were two different sets of "Rules of the Road at Sea" in use on board Her Majesty's ships, without any clear determination as to which was to be followed. One set of rules was that in use from time immemorial, and the other was that issued under order in council of 1863. He was much struck by the danger of the position, but the Admiralty did not agree to his proposition that it had become absolutely necessary to supersede the old rules by the new.

As fortune willed it, within a few days after this decision had been arrived at, H. M. S. *Amazon* collided with the steamship *Osprey* in the Channel, and both ships sank with some loss of life. Commander Colomb's submission was then agreed to, and he was desired to watch the case for the Admiralty, and in order to examine into the real state of the law, at the trials before the court-martial and in the Admiralty Court.

The state of the law seemed to him excessively dangerous, and from that date until the sitting of the Washington Conference in 1888, he was almost continuously employed in endeavours to bring about amendments. Changes in the directions he urged were from time to time introduced, but he was always —until about 1887—treated as in opposition, both by the Board of Trade and the Admiralty. About 1887 the Admiralty began to accept his views, and the main points were carried, by the help of the Admiralty delegates, at the Washington Conference, and are now law.

On Captain Colomb's recovery from his illness in 1874, he was appointed to command the *Audacious* as flag captain to Vice-Admiral Ryden on the China station. The three years' command there was without event, but after the return home a committee was appointed by the Admiralty to modify the systems of tactics and of signals after consideration of the reports from the fleet upon Captain Colomb's "Manual."

This committee sat in 1878. It was presided over by Rear Admiral Charles Hope; the next member in seniority was Captain, afterwards Vice-Admiral, Sir George Tryon; and Captain Colomb came third. Admiral Fitzgerald, in his "Life of Sir George Tryon," has given a most inaccurate and misleading account of this committee, which became, because of the *Victoria* disaster, of great importance and significance. Admiral Fitzgerald says:—

"Colomb had made a deep study of the subject of fleet tactics and the manœuvring power of ships, and had mapped it all out on paper. Tryon represented the practical side of the question, as distinguished from the theoretical side of it. He believed greatly in the training of the eye, to judge distance and speed, as the foundation of all successful fleet manœuvres. It was a strong committee. Colomb and Tryon represented somewhat divergent views with regard to the theory and practice of steam tactics, and Lord Walter Kerr and Admiral Hope held the balance."

The fact was that Captain Tryon was quite new to the whole subject, and had never before been consulted about it. All the books before the committee were Captain Colomb's own work, and that work had always been, as far as possible, experimental. The tactics were based entirely on a series of experiments prepared by Captain Colomb and carried out by Admiral Dacres in the Channel Fleet of 1865. These had been supplemented by others, carried out by Admiral Hornby in the Channel in 1871, and everything from first to last had been done in the closest correspondence with Admirals Dacres and Hornby, the best tacticians of their day.

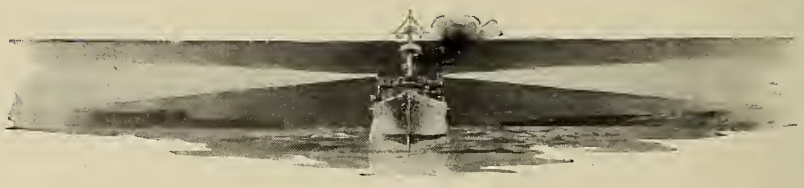
From the very first, experiment had shown the danger of trusting, as it was said, to "the eye and the judgment," in manœuvring, and the necessity of going farther, and of ascertaining what ships could and could not do had been almost a commonplace. Captain Tryon and Captain Colomb had long been friends, and remained close friends all through this committee. But Captain Tryon could not be persuaded that it was of importance for the captains of ships to go beyond their eye and judgment, and, carrying the committee with

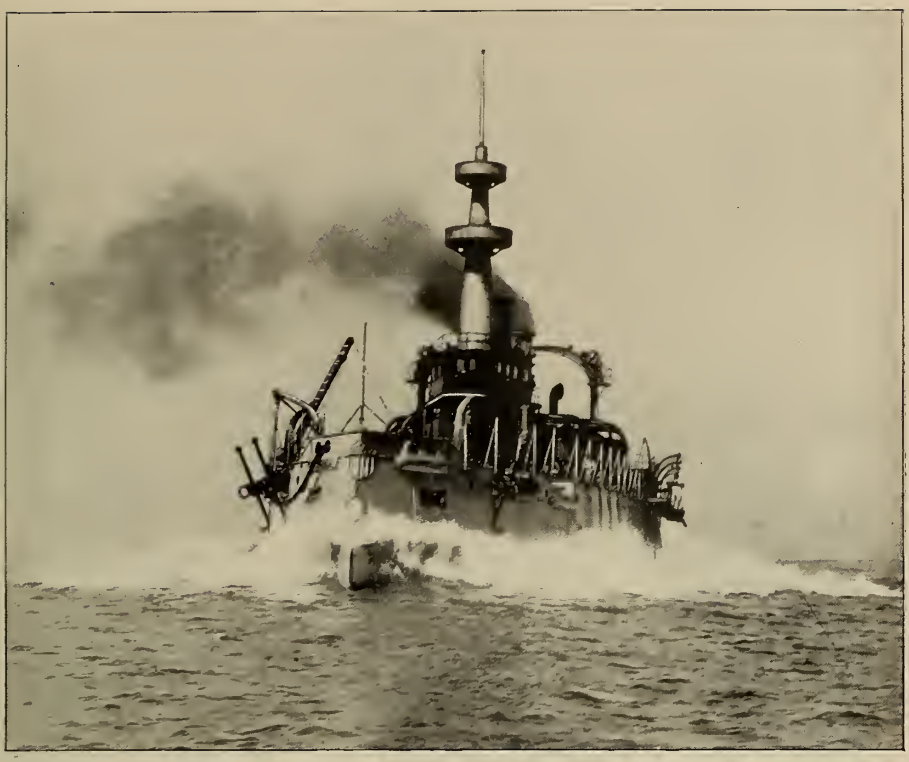
him, the additional information which was then obtainable in regard to manœuvring was not inserted. The chapters on manœuvring in the "Manual" remained as they left Captain Colomb's pen in 1874. The "divergent views" were between Admiral Hope and Captain Tryon, and the balance was held by Captain Colomb; otherwise the committee would have broken up.

Captain Colomb afterwards commanded the *Thunderer* in the Mediterranean, and, in 1881, became captain of the steam reserve at Portsmouth. He finished his active career as flag captain in command of the *Duke of Wellington* at Portsmouth, and was compulsorily retired from the service in May, 1886.

Since his retirement he has devoted himself chiefly to upholding the place of the navy in the State by voice and pen, using the freedom that his independent position gave him.

He became a Rear Admiral in 1887 and a Vice-Admiral in 1892. He wears the Burmese medal and also the Arctic and Baltic medals. He is a member of the Athenæum and United Service Clubs; a younger brother of the Trinity House, and a nautical assessor to the House of Lords. He is the author of several works on the prevention of collisions at sea; of Slave Catching in the Indian Ocean," "Naval Warfare," "Essays on Naval Defense," and other books, and has just completed a life of the late Admiral Sir Cooper Key.

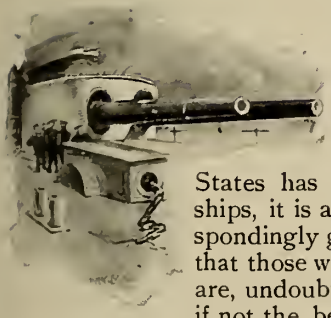




THE "OREGON" AT FULL SPEED.

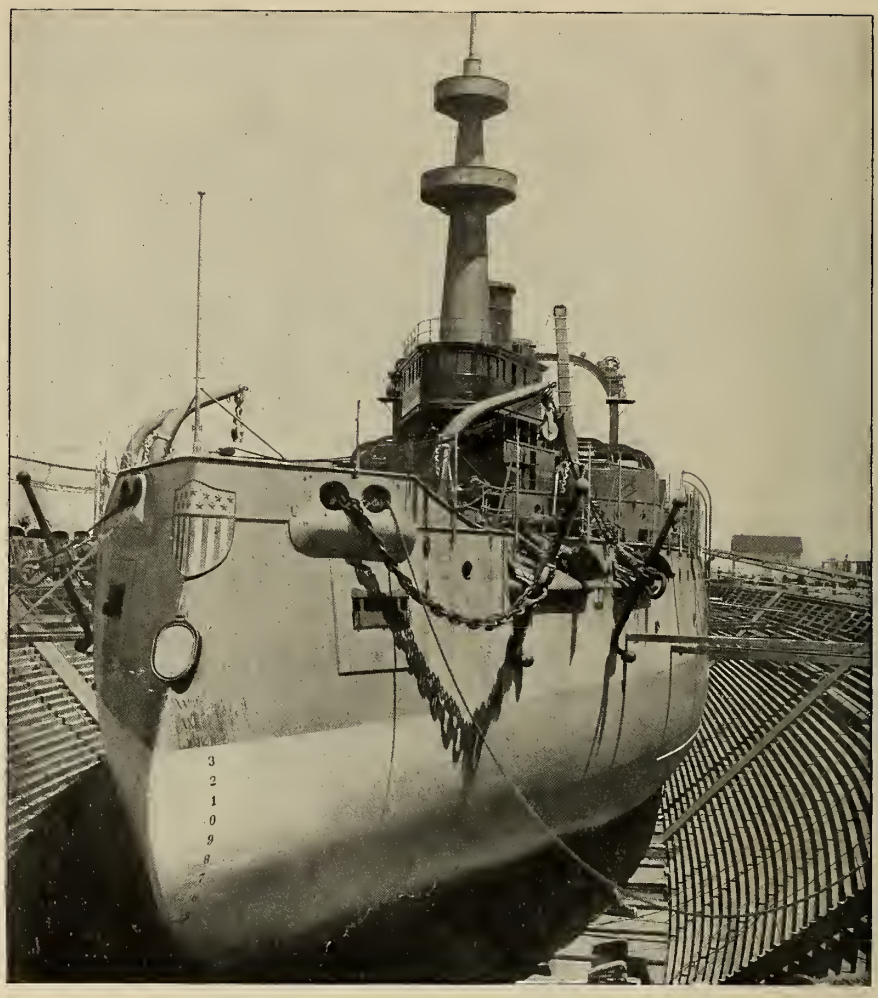
BATTLESHIPS OF THE UNITED STATES NAVY.

By George H. Shepard, Engineer Corps, U. S. N.



WHILE every American must regret at this time of Spanish conflict that the United States has not more battleships, it is a matter of correspondingly great gratification that those which are available are, undoubtedly, of the best, if not the best, in the world. There are larger warships and ships with heavier batteries, but any vessel of war is a compromise; and the combination of qualities in American battleships has been so judicious that it is universally conceded that the *Indiana* or *Iowa*, for example, could engage any battleship of any other nation with good prospects of success. This result is, of course, due, primarily, to the care, study, and ingenuity that have been bestowed upon the designs of these vessels by the responsible bureaus of the United States Navy Department; but credit is due also to the excellent material and workmanship that have been put into them.

The *Indiana*, *Massachusetts*, and *Oregon* are sister-ships. The first two are by the same builder, the William Cramp & Sons' Ship and Engine Build-



THE "OREGON" IN THE DRY DOCK.

ing Company, of Philadelphia. They are almost duplicates of each other. The *Oregon* was built by the Union Iron Works, of San Francisco. The difference in builders results, naturally, in some differences in the ships, of which the most important is that the *Oregon* has hydraulic power for steering and turning the heavy turrets, while the *Indiana* and the *Massachusetts* use steam direct.

As is well known, naval vessels are given thorough trials before acceptance by the government, and the results of the full-speed trials show, not the highest speed possible for a short spurt, but speed sustained at sea for four hours with only a moderate amount of forced draught,—equivalent in the *Indiana* class to the pressure of only one inch of water. The results of American battleships' trials compare very favourably with those of large battleships of other countries, and it is gratifying to note that the results agree very closely with the previous calculations, showing that the later vessels, now under construction, can be depended upon to come up to their estimates.

The severe tests of armour and guns in the proving ground before acceptance are more or less familiar to the general

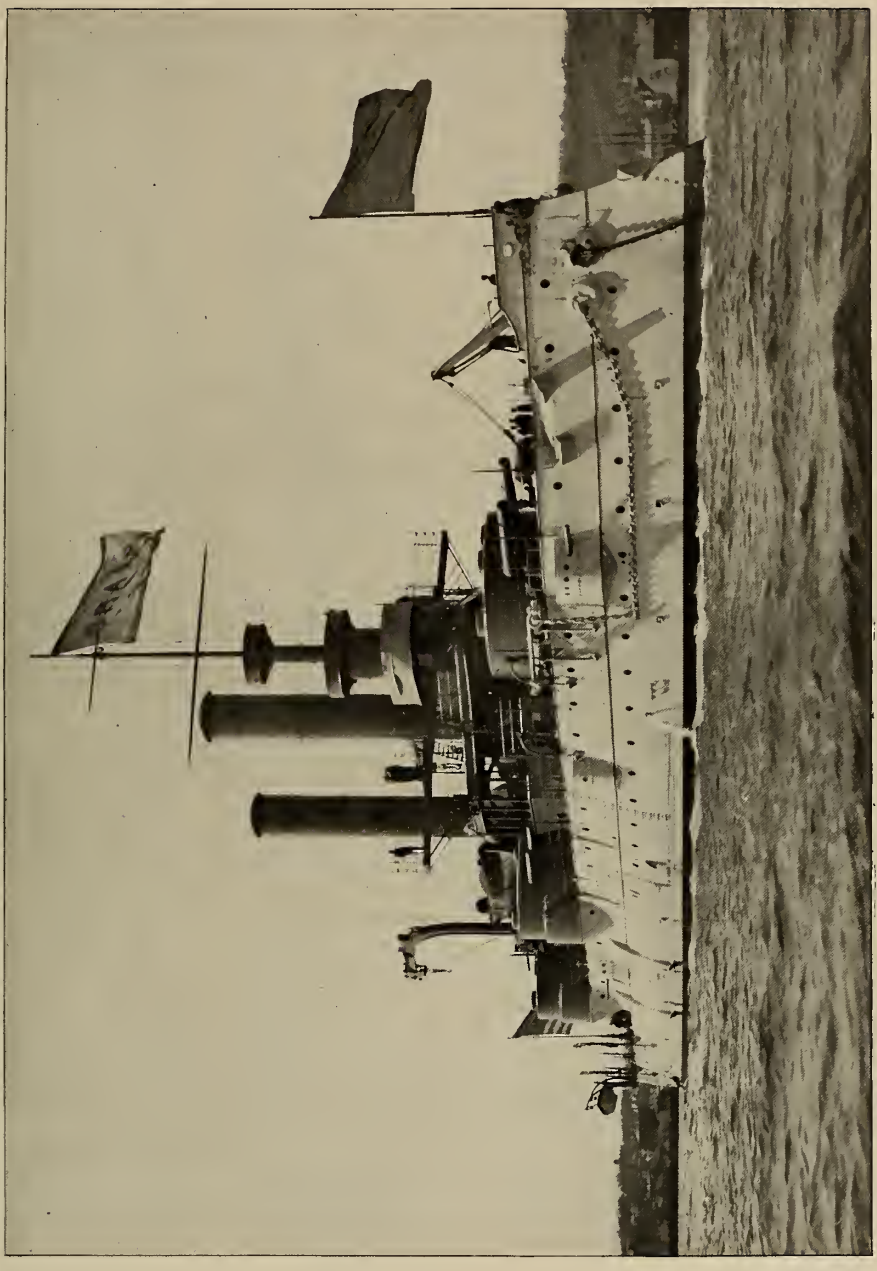
public, but it may not be commonly known that the entire defensive system of the battleships has given very satisfactory results under tests quite as severe as any likely to be encountered in actual battle. A structure representing a turret for the *Massachusetts*' 13-inch guns was tested in the proving ground by gun attack, and the result showed that the turret structure was sufficiently strong and rigid to answer all requirements, to hold the armour up in shape, and to retain its general shape even though the armour might be entirely pierced locally. It also showed that turret armour 15 inches thick would keep out 12-inch projectiles with attacking service velocities.

A structure representing the armoured side of the *Iowa* was similarly tested. The projectiles were gradually increased in penetrating power, until the armour was finally completely pierced; nevertheless, the frame-work sustained only comparatively slight injury. In the words of Captain W. T. Sampson, U. S. Navy, then the chief of Bureau of Ordnance, the result showed "that the strength of structure supporting the fixed armour of our battleships is sufficient to hold this armour in place when subjected to the limit of its endurance; that, whatever fate might betide the armour plate when attacked by the most powerful guns, whether cracked, or broken, or wholly penetrated, still it would be so supported as to develop its known power of resistance."

As may be inferred from the above, the armour of these vessels is not absolutely impenetrable. The days have passed when vessels could be covered in every exposed part with armour that could resist any gun afloat at point-blank range; but the belt and 13-inch turret armour of the *Indiana* class will resist any gun afloat at any range that is likely to be used in battle; and the armour of their 8-inch turrets can be pierced at like ranges only by the heaviest guns in an enemy's battleship.

INSIDE A TURRET ON BOARD THE "MASSACHUSETTS."

THE COAST LINE BATTLESHIP "OREGON." TWIN SCREWS. DISPLACEMENT, 10,231 TONS. I. H. P., 9000. SPEED, 15 KNOTS.
BUILT BY THE UNION IRON WORKS, SAN FRANCISCO, CAL.



THE SEA-GOING BATTLESHIP "IOWA." BUILT BY THE WM. CRAMP & SONS SHIP AND ENGINE BUILDING CO., PHILADELPHIA.

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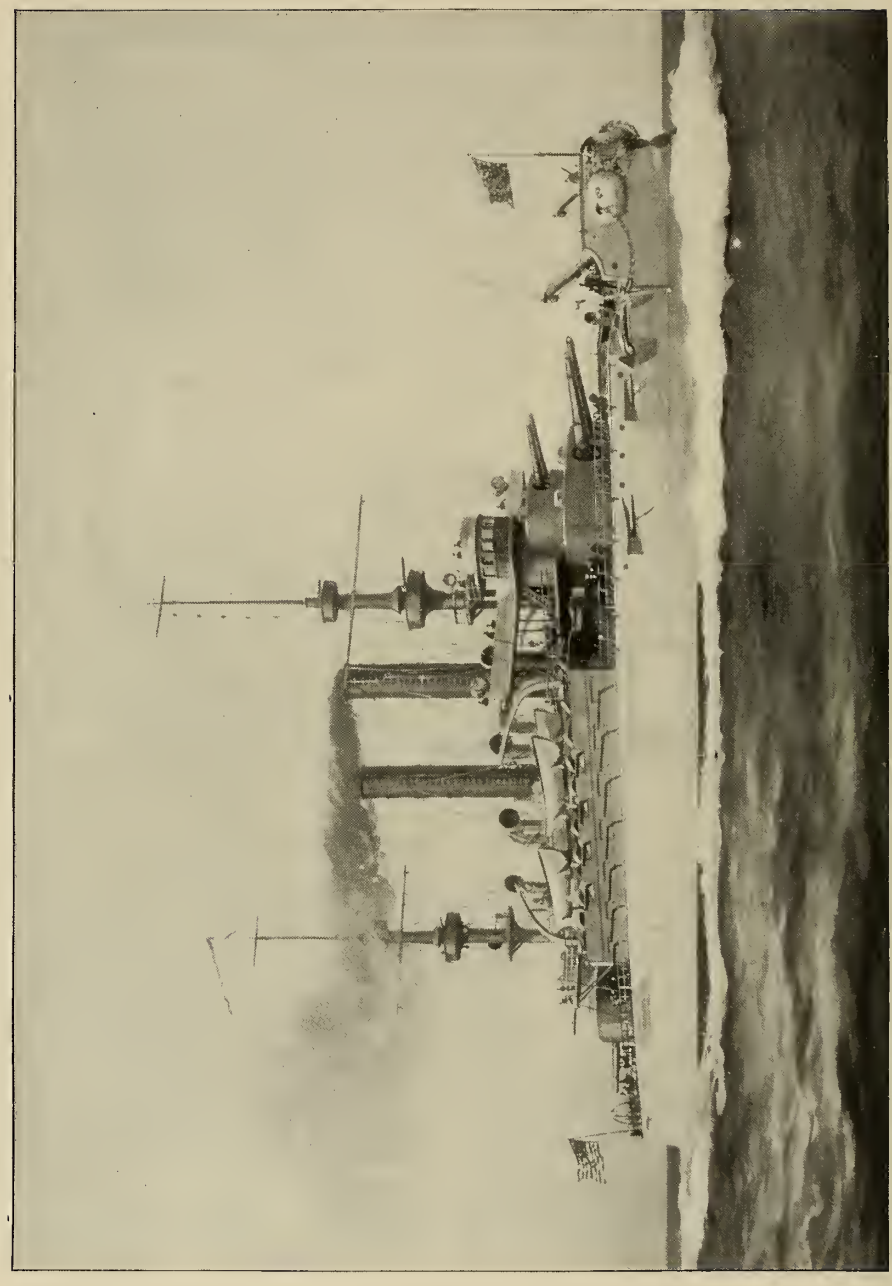

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THE UNITED STATES BATTLESHIP "KENTUCKY," NOW UNDER CONSTRUCTION IN THE YARD OF THE NEWPORT NEWS SHIPBUILDING AND DRY DOCK CO., NEWPORT NEWS, VA.

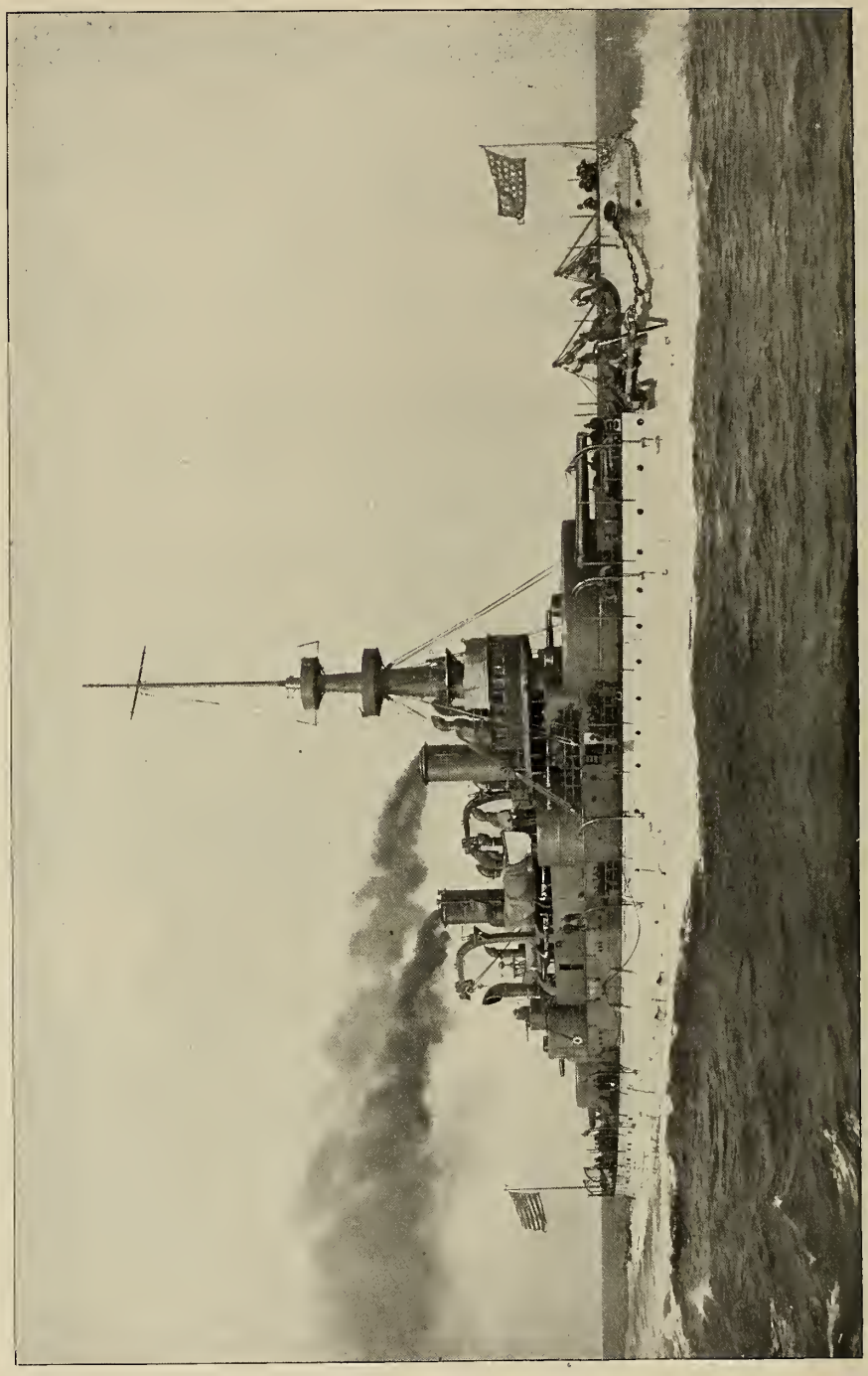
Both the *Indiana* and the *Iowa* type have given splendid satisfaction in service, and experience with them will show their strong and weak points and will be of great value in designing later ships. All naval experts agree that similarity between all the vessels of a given class in any one navy is very desirable. The *Indiana* and *Iowa* are alike in many respects, and the later battleships are compromises between them, so that the battleship fleet so far possesses a marked degree of homogeneity. The United States is the more to be congratulated on this, as the authorities have to depend upon the appropriations that Congress may make from year to year without being able to know what to expect in the future from such definite and well-conceived ship-building programmes as European powers set before their designers.

The *Indiana* is a twin-screw coast line battleship, built on designs furnished by the United States Navy Department. Her contract was signed on November 19, 1890, and required her to be completed in three years for a price of $3,063,333. The makers guaranteed a speed of 15 knots per hour for four consecutive hours with an air pressure of not more than 1 inch of water on a mean draught of 24 feet of water. The speed premium was $25,000 for every quarter knot above 15 knots, and the penalty was $25,000 for every quarter knot below that speed.

The vessel had her official full power trial on October 18, 1895. She had then been nineteen months out of dry dock; but, as she had been all the time in the fresh water of the Delaware river, and as the nearest dry dock then capable of taking her was at Halifax, her builders decided that she was not foul enough to make it pay to have her docked. As a result she made only 15.55 knots, which, though in excess of the contract, was a good deal less than that of her sisters, the *Massachusetts* and the *Oregon*.

THE UNITED STATES BATTLESHIP "TEXAS." DISPLACEMENT, 6300 TONS. INDICATED H. P., 8600. SPEED, 17 KNOTS. BUILT AT THE NORFOLK, VA., NAVY YARD.

Naval experts are divided as to the importance of high speed for battleships; but they are all agreed on the value of heavy armour and powerful armament. The United States Navy Department has held steadfastly to the opinion that, for battleships, a knot or two of speed could well be sacrificed for greater offensive and defensive powers; and the majority of American officers believe that the department has been wise in so doing. In consequence American battleships are



THE COAST LINE BATTLESHIP "INDIANA." TWIN SCREWS. DISPLACEMENT, 10,233 TONS. I. H. P., 9000. SPEED, 15 KNOTS.
BUILT BY THE WM. CRAMP & SONS SHIP AND ENGINE BUILDING CO.

somewhat slower than those of other nations, but in armour and armament they are superior to the latter. Even in the matter of speed, there are compensations. The ships will probably always operate near the American coast, and, therefore, with bottoms cleaner than those of an enemy operating against them from a distant base. Moreover, the *Indiana* class have as much boiler power as larger battleships of other nations that are credited with higher speed, so that the superiority in speed of these latter is likely to be rather nominal than real.

Another good feature about the *Indiana* is the comparatively high speed that she has made under natural draught. On March 27, 1894, she was given a builder's trial of three double runs over a course on the Five-Fathom Bank off the capes of the Delaware, preliminary to the official full-power trial. On this occasion, with natural draught, she made 14.08 knots; with an air pressure of ½ inch of water in the fire-rooms, 14.93 knots; and, with an air pressure of 1 inch of water, 15.25 knots.

Before warships are finally accepted, they are given what is called a "final trial," after they have been some months in commission. The object of this trial is to determine whether the ship, machinery and guns are then in all respects satisfactory at sea. No effort is made to force the ship to her utmost speed, as that is positively determined by her full-power trial. The *Indiana* had her final trial off Sandy Hook in April, 1896, and, although she was not pushed, she made about 13.6 knots with about 4550 I. H. P., less than half her full power. At this time she had just come out of dry dock, and her bottom was clean.

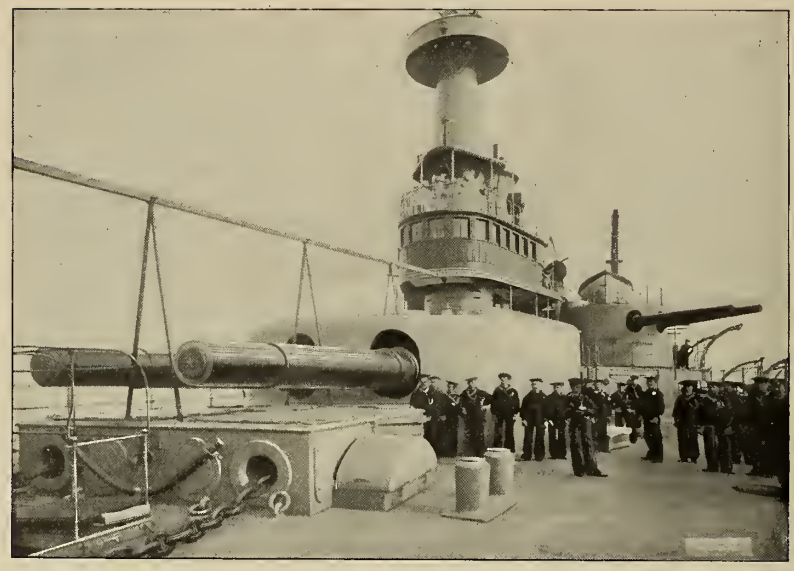
The *Indiana* and her class were designed to have bilge keels; but, at the time they were completed, docking facilities in the United States were so inadequate that the bilge keels had to be left off. In spite of this, the behaviour of the ships at sea was usually all that could be expected of vessels of their type. On account of their low freeboard, they are, of course, wet, if the weather is at all rough; but, even without bilge keels, they seldom encountered weather that would have prevented them from using their guns.

On one or two occasions, however, the *Indiana* showed excessive rolling. On her way from Hampton Roads to New York in the fall of 1896 she encountered a very heavy gale, in which her forward 13-inch turret broke loose. This turret is unbalanced, its centre of gravity being about 3½ feet from its axis of rotation, and its revolving weight about 489 tons. Any seafaring man can appreciate from these figures that the breaking loose of this turret in a gale of wind constituted a serious emergency. By prompt and skilful action the turret was secured temporarily by hawser. After reaching port, stronger securing gear was fitted. This was the most serious accident that has ever happened to any of these vessels.

In February, 1897, the United States North Atlantic Squadron encountered heavy weather off the coast of North Carolina. The *Indiana* began to roll so heavily that her commanding officer requested and received permission to put back into Hampton Roads. These events showed the need of bilge keels; and, as soon as possible, these were fitted. Later, the *Massachusetts*, on a trip from Boston to St. Johns, passed within 250 miles of a cyclone centre and encountered tremendous gales and very heavy seas. The vessel slowed down during the worst of the storm. With reference to it, her commanding officer reported:—

"During this time the ship behaved beautifully, never making less than 6 knots per hour, nearly, on her course, and never rolling over 5 degrees. Her steadiness was so remarkable during the entire passage that it must be, in great measure, attributed to the bilge keels."

In general, the manœuvring and steadiness of the *Indiana* and her class have been all that could be expected of short, broad, and rather shallow vessels, and they steer remarkably well. Turning trials of the *Indiana* showed a tactical diameter of only three times



THE FORWARD DECK OF THE "MASSACHUSETTS."

her length, which is uncommonly small.

The armament of the *Indiana* and her class consists of four 13-inch, eight 8-inch, and four 6-inch guns, twenty 6-pounders, six 1-pounders, four machine guns, and six torpedo tubes, one in the bow, one in the stern, and two in each broadside. The bow tube has lately been closed up.

The 13-inch guns of this class can be loaded at any point of train. By this means the guns can always be kept pointed at the enemy without the necessity, after every discharge, of revolving them to a loading position, as in many ships of other powers. Much time may thus be saved, and the guns, further, present the smallest possible target to the enemy, thereby minimising the danger of injury from opposing gunfire.

The vessels also have an excellent system for supplying ammunition to the guns while in action. On the platform below the protective deck there are two roomy, well-lighted passages, one on each side of the ship, extending from the base of the forward to the base of the after turret. On going into action a good supply of ammunition would at once be taken from the main magazines and stowed in auxiliary magazines opening off the passages. Each gun would thus have its ammunition directly beneath it, and there would be no confusion or shifting about of ammunition below. No better system of supplying ammunition has ever been devised.

The *Indiana* and her class have a six-foot coffer-dam forward and abaft the belt armour, all along the waterline. This coffer-dam can be filled with water-excluding material, such as cellulose or American corn-pith. It has been thoroughly demonstrated by practical tests that, on the penetration of such a coffer-dam by a projectile, the water flowing through will cause the water-excluding material to swell so that the inflow of water will be entirely stopped in a very short time. This is depended upon to prevent the ship from losing her stability, no matter how much her water-line may be penetrated at the ends.

The *Massachusetts* had her full-power trial on April 25, 1896. Her trial displacement was 10,265 tons; mean draught, 23 feet 11¼ inches; I. H. P., 10,403; and speed, 16.20 knots. She had been five months out of dock at the time, and her bottom was rather foul.

The *Oregon* had her full-power trial

on May 14, 1896. Her trial displacement was 10,250 tons; mean draught, 23 feet 11 inches; I. H. P., 11,111; and speed, 16.79 knots. She had been less than one month out of dock at the time, and had a clean bottom.

The *Iowa* is of a somewhat different type from the *Indiana* and her sisters. She is of about 1000 tons greater displacement than the latter, and is designed to have slightly less gun power and armour than they, combined with greater coal endurance, higher freeboard forward, and slightly greater speed. The *Iowa* can keep the sea to a greater extent than the *Indiana* class, and is known as a sea-going battleship, while they are called coast-line battleships. Her actual qualities come fully up to what was expected of her by her designers; and, in fact, she can carry more coal than was estimated without exceeding her calculated displacement.

The *Iowa* had her full-power trial early in 1896. The trial displacement was 11,340 tons; mean draught, 24 feet; I. H. P., 12,105; and speed, 17.09 knots. She ran twice over a thirty-three-mile course off the New England coast, the two runs being in opposite directions, and the second following immediately after the first. With tidal corrections, the distance steamed through the water was 66.3407 knots, and the true mean speed 17.0871 knots. The weather was good and the machinery worked well.

The final trials took place off Sandy Hook in November 1897. One of them was a full natural draught power run for two hours. The bottom was foul at the time as the ship had not been docked since the preceding March. The regular engineers' force ran the trial alone without help from the deck force. The data of this final trial were:—Draft forward 22 feet 6 inches; aft 24 feet 7 inches; mean 23 feet 6½ inches; displacement 11,080 tons; speed 13.2 knots; 10.88 I. H. P. were developed and 25.2 pounds of coal were burned per hour per square foot of grate, showing the benefit of the tall smoke stacks, which rise 100 feet above the grates.

The *Texas* is a second-class battleship. There was a time when she was

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SOME OF THE 13-INCH GUNS OF THE "INDIANA."

commonly known as "the poor old *Texas*," but lately not much has been heard of that. While the *Texas* is not a ship that can be regarded with the same pride as the *Iowa* and the *Indiana* and her class, she is by no means the lame duck that a good many people imagine.

Her designs were British and were purchased by the United States Navy Department as the result of a prize competition. She was built at the Norfolk Navy Yard by Naval Constructor Francis T. Bowles, U. S. N., now the head of the construction department of the New York Navy Yard. While she was still on the ways, certain officers claimed that she would float so deeply below her calculated water line that she would be entirely useless. The Navy Department had her plans thoroughly gone over, and decided that the calculations were correct. Her construction was therefore continued, and she was launched in July, 1892.

After being placed in commission she was docked at the New York Navy Yard. It was then discovered that her bottom plating was not strong enough, and she was returned to the Norfolk Yard, put out of commission, docked, and her bottom plating was strengthened. After the completion of these repairs she was again placed in commission. In July, 1896, she ran aground in the harbour of Newport, R. I., an event which brought forth the usual avalanche of unfavourable press comments.

In November, 1896, the *Texas* distinguished herself by a unique accident. While at the New York Navy Yard, she settled peacefully to the bottom alongside the dock. At the time one of her main injection pipes was out for repairs; and the yoke holding the main injection valve suddenly broke, admitting a solid stream of water the size of the pipe. This yoke was of cast-iron, contrary to the usual navy practice, which is to make such yokes of composition metal. A good deal was heard at the time in the press to the effect that the *Texas* was likely to go to the bottom at any time at sea, in the same manner; but at sea the injection pipe would always be in, the valve open, and the pipe full of water, so that such fears were quite groundless. Last summer the *Texas*' steam launch blew up, which concludes her chapter of accidents.

She had at one time a serious defect, in that her turret guns could be loaded in only two positions; and one of these her officers held to be impracticable in a sea-way. Thanks to one of her own officers, Lieutenant Haesler, this has been completely remedied, and her turret guns can now be loaded in any position.

In speed she is one of the best of the United States battleships, being about as fast as the *Iowa*.

To the vessels thus far mentioned, all of which are in active service, are to be added five other battleships, the *Kentucky* and *Kearsarge*, and the *Alabama*, *Wisconsin*, and *Illinois*, which are now in various stages of construction at the Newport News Shipbuilding and Dry Dock Company's yards, at Cramp's, and at the Union Iron Works.

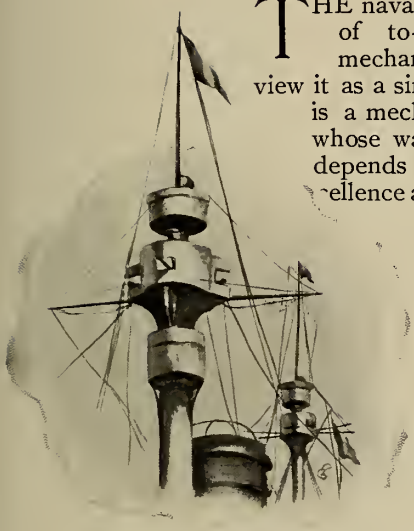
It seems proper, too, before closing this brief sketch that some mention should be made of the ill-fated battleship *Maine*, which was blown up in the harbour of Havana last February. She was built at the Brooklyn Navy Yard, her keel being laid in October, 1888, and her most important mission was that which ended in her complete destruction at Havana, whither she had been sent to protect American residents from prospective riot dangers.

The vessel carried four 10-inch guns in two turrets, one forward on the starboard beam, and the other aft on the port beam. In addition to these, which formed the main battery, she carried six 6-inch guns and a well-equipped rapid fire battery.

MECHANISM OF MODERN NAVAL WAR.

By Charles H. Cramp.

Extracts from an Address to the United States Naval War College.



THE naval armament of to-day is a mechanism. If we view it as a single ship it is a mechanical unit whose warlike value depends on its excellence as a fighting machine. If we view it as a fleet, it is an assembly of mechanical units, the warlike value of which will depend alike on the excellence of each unit as a fighting machine, and on the adaptation of each unit to its consorts to produce the most symmetrical efficiency of the group as a whole.

For this reason the word seamanship in the old-fashioned or conventional sense has ceased to cover adequately the requirements of knowledge, skill and aptness which the modern conditions of naval warfare impose upon the officer in command or subordinate.

By this I mean not to depreciate seamanship pure and simple, but to point out that modern conditions require an enlargement of the meaning of the term and a broadening of its scope of function far beyond the exactions of any former period.

In the old days there was no essential difference in ships except in size. Experience in a sloop of war qualified an officer to assume at once and in full efficiency equivalent duties in a frigate, a seventy-four or a three-decker. Familiarity with one ship, irrespective of rate, was familiarity with all ships. Tactical lessons learned in manœuvring one fleet were alike applicable to the manœuvring of all fleets. Even the application of steam as a propulsive auxiliary in its earlier stages did not radically alter the old conditions. At all events it did not practically erase them as the stage of progress at this moment has done.

I cannot better illustrate my point than by comparing the first and the last sea-going battleships built and delivered to the United States government by Cramp. The first was the *New Ironsides*, built in 1862. The last is the *Iowa*, completed in 1897. Each represented or represents the maximum development of its day.

The *New Ironsides* had one machine —her main engine, involving two steam cylinders. The *Iowa* had seventy-one machines, involving one hundred and thirty-seven steam cylinders.

The guns of the *New Ironsides* were worked, the ammunition hoisted, the ship steered, the engine started and reversed, her boats handled—in short, all functions of fighting and manœuvring—by hand. The ship was lighted by oil lamps, and ventilated, when at all, by natural air currents. Though, as I said, the most advanced type of her day, she differed from her greatest battleship predecessor, the old three-decker *Pennsylvania*, only in four inches of iron side armour and auxiliary steam propulsion. She carried fewer guns on fewer decks than the *Pennsylvania*, but her battery was, nevertheless, of much greater ballistic power.

In the *Iowa* it may almost be said that nothing is done by hand except the

AN OLD-TIME SPANISH GALLEON IN BATTLE.

opening and closing of throttles and pressing of electric buttons. Her guns are loaded, trained and fired, her ammunition hoisted, her turrets turned, her torpedoes—mechanisms of themselves—are tubed and ejected, the ship steered, her boats hoisted out and in, the interior lighted and ventilated, the great search-lights operated, and even orders transmitted from bridge or conning tower to all parts by mechanical appliances. Surely no more striking view than this of the development of thirty-five years could be afforded.

This growth of complexity and elaboration, and this almost infinite multiplication of parts and devices, have entailed upon the naval architect and constructor demands and difficulties never dreamed of in the earlier days. The staff required to design and construct an *Iowa* is multiplied in number and the complexity of its organisation augmented as compared with that required for the design and construction of the *New Ironsides* almost infinitely.

Similar conditions apply to command and management, so that while the building of a modern battleship entails enormous work and responsibility on the naval architect, constructor and staff, the effective use of her as a tool in the trade of war presents an equal variety and intricacy of problems to students of the art of naval warfare.

Such questions and such problems cannot be relegated to the category of details. Even if we consider the art of naval warfare in the aspects only of strategy and tactics, both will be affected for better or for worse by the behaviour and performance of the units composing the force in operation. This being admitted, it follows that the behaviour and performance of the units will be as the knowledge and capacity of the captains and their staffs; and that no extent of skill and capacity in the admiral directing the whole can overcome or evade the consequences of incapacity and failure on the part of a captain commanding a part.

Necessarily the employment of battleships for the enforcement of sea power involves their operation in fleets or squadrons.

The experience of war may, and probably will, modify prevailing ideas, and set a limit to the number of battleships that can be safely or effectively manœuvred in squadron. It is more than probable that at an early stage of action the commanding officer of a battleship fleet or squadron will find it necessary to signal for each captain to do the best he can. And it is possible that fleet or squadron tactics, as now received and understood, will be found to impede, if not destroy, the efficiency of modern battleships in action.

No action having occurred between fleets of modern battleships, the tactical conditions must be somewhat conjectural, or at least theoretical; but the experience of peace drills and manœuvres has demonstrated that the elements of difficulty and danger due to modern appliances, as compared with the conditions of the great sea fights of history, have been multiplied manifold.

For example, at Trafalgar, the *Victory*, *Temeraire*, and *Redoubtable* were foul of each other for a considerable period. None of these ships of the line sustained any injury worth mentioning from the fouling alone. I presume no one imagines that three modern battleships could be foul of each other for many minutes before some of them would begin to sink from the effects of contact alone and irrespective of any execution done by their batteries or torpedoes.

This ever-present danger is equally great from friend and from foe, and the fact that it must be vastly increased by the circumstances of action will devolve upon the commander of the fleet and upon each one of his captains responsibilities of which Rodney and Nelson and their captains never dreamed.

These facts suggest a wide range of problems, embracing not only tactics, which is outside of my province, but design, structure, manœuvring appliances, in short, everything that pertains to handiness, controllability under various conditions and ultimate safety after a maximum of injury. The fate of the

Victoria demonstrated that subdivision into water-tight compartments is useless if communication between any number of them is left free, and that water-tight doors, at least as arranged in that ship, cannot be closed against much head of inrushing water.

Above all, it demonstrated that captains differ in capacity and in promptness, and that such difference, operating in the brief time allotted to a single manœuvre, may easily be fatal to a ship, or, in action, to a fleet. This is a case of the personal equation; the operation of the human factor, which is always unequal to an immeasurable degree if we consider the possible extremes of capacity and incapacity; but at best always subject to error, and hence calculated to defeat or mar in greater or less degree the efficiency of the most skilfully designed and most perfectly constructed mechanical devices. This is a fundamental fact, having its origin in the organic weakness of human nature, and hence unavoidable. At best, its consequences can only be mitigated.

In view of the complex character of the ships themselves, and the difficulty and danger of manœuvring them under the most favourable conditions, the experience of the first general action will demonstrate the necessity of having all the battleships in a fleet as nearly alike as possible in size, type, and capacity of performance. Such provision would not equalise the personal factor of different commanding officers, but it would at least give them all an equal chance at the start.

For this reason I have always considered it unwise to multiply types or to seriously modify those which the best judgment we are now able to form approves. The practice of the British, French, Russians and Germans has been contrary to this idea. Each new administration of their navies has brought in new types, until their navy lists present an almost bewildering variety.

The United States Navy has not accumulated an assortment of battleship types, and hence is free to pursue the desirable policy of uniformity. The very first attempt at battleship design in the United States produced a type which I consider the fairest compromise of all divergent qualities and necessities yet reached anywhere. The resulting ship carries on a displacement of 10,400 tons, armour and armament superior to British ships of 14,150 tons, is equal to them in manœuvring speed, and much quicker and handier under helm.

The second effort produced a ship which is, in some respects, a modification of the first. The changes are mainly in the direction of greater freeboard and a knot more of speed, involving 1000 tons more displacement, by which the all-around sea-going efficiency is expected to be increased; but as a fighting ship pure and simple, I think no one contends that the *Iowa* is an improvement upon the *Indiana* class. Without going into detail of the differences between the two ships, I will say, generally, that a ship of the *Indiana* class is able to combat any first-rate battleship afloat as to armour and armament; she has as much speed as will ever be needed for manœuvring purposes, and her coal capacity is sufficient for any cruise that the policy of the United States will ever require in war.

When to these offensive and defensive qualities is added the fact that the *Indiana* developed on her preliminary trial a readiness of response and fidelity of direction under helm little short of marvellous, in view of her dimensions and weight, she becomes by great odds the handiest first-rate battleship afloat. In the language of her navigating officer on that occasion, "she steered like a pilot boat."

In my judgment, it is hardly possible to overvalue the importance of homogeneity in fleet organisation, and I am sure that the very first, and perhaps the greatest lesson taught by an encounter between fleets of modern battleships will be the advantage of similarity of type and equality of performance in the units of action.

Having viewed the modern battleship as a mechanical unit herself, we may profitably pass to brief consideration of the great number and variety of mech-

anisms composing her. In the strict professional or technical sense these mechanisms concern mainly the engineer and the electrician. But as the foundation of all warlike efficiency in personnel is discipline, and as the foundation of all discipline is the inevitable principle of a single head, one commander, who is to all intents and purposes an absolute monarch, it should follow that "the King can do no wrong."

I have already remarked that the captain need not be a naval architect or constructor to comprehend and be able to apply the group of principles of that art which touch his functions directly in managing his ship as a whole; likewise I would say here, that he need not be engineer or electrician in his relation to the numerous and diverse mechanisms whose proper operation and control are essential to the efficiency of his command.

But, if he really commands, he must know enough about the instruments that do his work to know when they are doing it well and when not; to know whether his subordinates immediately in charge of the several devices are operating them properly or not; to know when defects exist and when they have been made good. If he does not know, or cannot learn these things, he must depend wholly on subordinates immediately in charge, and their reports will be law to him, or if not law, at least decisions from which he has no appeal. Manifestly such a situation is utterly incompatible with the independent and self-relying autocracy which is the essential and fundamental principle of naval command, and without which discipline must sooner or later vanish into mere empty form or conventional myth. These facts, even more than any other considerations, argue for uniformity of type, previously touched upon, so that in learning the traits of one battleship the officer acquires experience and knowledge applicable at once to the discharge of his duties in another.

I desire here to emphasise a distinction. A man who has successfully commanded a battleship, and has mastered the seamanship which I have described by that title, is qualified to command any other type or class. But it does not follow that a man who has been the successful commander of a cruiser or a gun-boat is thereby qualified to command a battleship, because the latter is the graduating point of all seamanship in our time.

From this point of view the captain of the modern battleship finds himself at the parting of two roads as soon as he reads his orders and breaks his pennant. One road is that of taking things easy, relying blindly on subordinates in all the different branches of the ship's economy, accepting trustfully every report that may come to him.

The other road is the hard one. I need not describe it *in extenso*, but simply say that it is the road of study, vigilance, inspection, supervision, insight—in short, actual command in the broadest practical sense, in fact as well as in name.

The first road, as I said, is easy, and, if all were fair weather and smooth water, might lead to what would pass for success, if not distinction. But any emergency would end that road in the mire.

The last road is hard to travel, but when it leads into an emergency the captain is found prepared, self-reliant and able to command his subordinates on the spot, instead of waiting to receive their reports. This brings success of the kind that cannot be hid, and with it that valuable and permanent distinction which the public is always ready and anxious to confer upon those who serve it well.

The foregoing discussion is limited to matters affecting the unit of action—the single ship and the captain. Passing to consideration of the unit of operation, the fleet and the admiral, we find another array of problems.

Let us assume that the composition of the fleet has been made as nearly homogeneous as possible by carrying out the principles previously stated as for ships and their captains, and that the admiral finds himself in command

of an ideal fleet as to material and personnel. Actual differences in efficiency as between the several units of action will still remain, and it will become the first duty of the admiral to ascertain and locate these diversities with unerring judgment and unsparing perception. He should know to a nicety the personal equation of every captain and the effective individuality of every ship.

Among the captains he should be able to differentiate the traits of relative quickness of perception, promptness of action, readiness of responsibility and boldness of execution.

He should know precisely the steering quality of every ship at every speed, which would, of course, include her circle and her time of altering course in any degree, from a fraction of a point to wearing clear around.

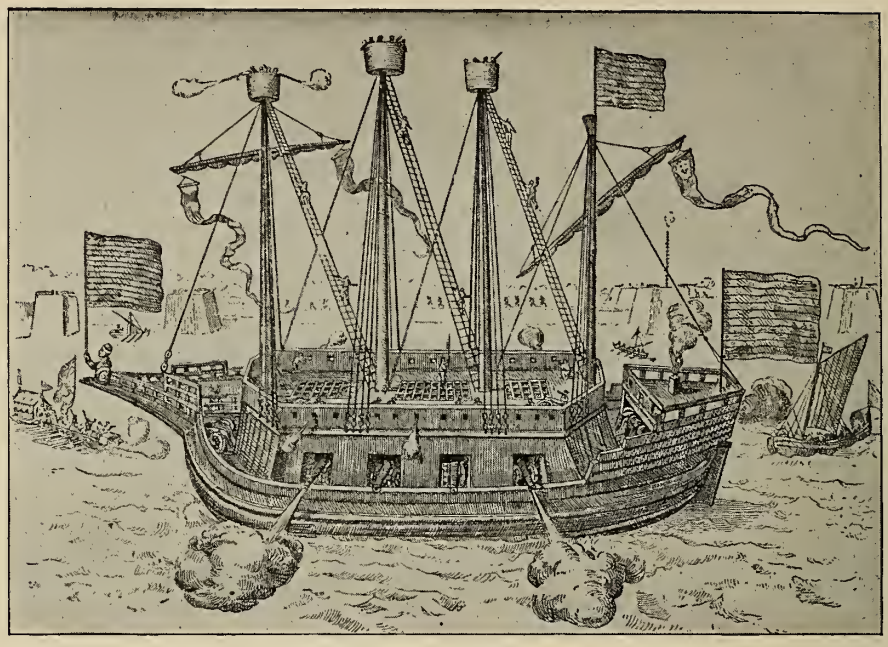
In a word, the admiral should have clearly and definitely in his mind a true conception of the coefficient of performance of each unit of his command in all situations, and he should be able at any time and in any emergency to relate these coefficients to each other and to the whole with infallible precision. If it happens that the least competent captain has the least effective ship, and the ablest captain the best ship, the range of coefficients will be wide; if the conditions are reversed, giving to the poorest ship the best captain, and to the best ship the poorest captain, the range of coefficients may be narrowed, but there will always be some diversity, and the tact and skill of the admiral must be measured by his success in reducing the tactical effect of such diversity to a minimum.

It may be suggested that the schedule of requirements just formulated presupposes almost superhuman capacity in the admiral, both as to range of knowledge and accuracy of judgment. If so, I maintain that the command of a fleet of modern battleships, on whose success in a campaign the issue of a cause or the fate of a nation may depend, is by far the greatest trust that can ever in our time, or in the future, be confided by a people to one man.

Current Topics.

With the exception of the now famous battle of the Yalu, which was fought during the late war between Japan and China, there was not, until recently, anything on record to show what modern naval ordnance could do against modern ships of war. The Yalu fight itself furnished but incomplete evidence of war engine efficiencies because of relatively untrained men behind the guns, and the conflict between the United States and Spain, therefore, has to be looked to by the naval powers of the world for lessons of real value as to the possibilities in modern naval engagements. With the making, in this war, of important history, naval literature has suddenly become of commanding interest, and the present number of Cassier's Magazine, therefore, has been devoted entirely to ships of war and their equipment, and to some of the noteworthy naval doings of earlier years. The great expectations which are entertained by many eminent naval authorities of the value of the ram as an instrument of modern naval warfare, lend a special interest at this time to the article on that type of vessel which appears in this issue, and the picturesque account of the defeat of the Spanish Armada, three hundred years ago, will similarly appeal to readers everywhere. Each of the other articles as well has been prepared by a competent authority, making, altogether, a notable series of contributions.

A very good illustration of the important position which auxiliary steam machinery nowadays occupies aboard ship, as compared with the main engines, is afforded by the simple statement in one of the annual reports of the chief of the United States Bureau of Naval Equipment that of the total quantity of coal burned by United States naval vessels during one year, only 45 per cent. was used for steaming purposes, the remainder being consumed for the auxiliaries. In one particular case,—that of the cruiser *Philadelphia*,—only 764 tons were consumed in cruising, while 2324 tons were used up for the various electric light engines, pumps, hoists and others which help to make up the ship's machinery equipment. Such figures are suggestive in several ways. They point, as indicated, to the great quantity of auxiliary machinery carried on a modern vessel, and, further, to possibilities in the way of fuel economy which might be realised by giving this machinery greater



THE DUTCH IRONCLAD "FINIS BELLI," 1585.

efficiency all around. Up to the present time steam economy in the auxiliaries has frequently had to give way to simplicity of design and to the great desideratum of saving weight and space, which naturally would be much affected by compounding the engines and by adding feed water heaters and other coal-saving devices in accordance with the most approved practice on shore.

It is interesting to recall at the present time the idea, conceived early in this century,—in 1812,—by Colonel John Stevens, for the construction of an iron-plated vessel of war with a saucer-shaped hull, propelled by screws so arranged as to give a rotary motion to the structure. The battery, as told by Dr. Robert H. Thurston, in an article in this magazine several years ago, was to be of the heaviest ordnance of the time, and the plating heavy enough to resist the shot of similar guns at short range. The main purpose of the craft was harbour defense, and the plan of action was to moor the vessel by a chain leading down through the bottom of the ship at its centre, and to spin it around this centre, firing gun after gun as it came in the line of fire, thus anticipating the later Timby turret, which, in turn, was the germ of the modern "monitor" armourclad. Such a vessel was actually built, half a century later, by the Russian government, and was a good representative of the first Stevens battery.

Dr. Thurston, in that article above referred to, made interesting mention also of the claims, by some authorities, that the Dutch were the first in the modern period of history to build an ironclad, and that during the siege of Antwerp by the Spaniards, in 1585, the people of that city built an enormous flat-bottomed vessel, armoured it with heavy iron plates, and thus constructed what they regarded as an impregnable battery. This they named *Finis Belli.* According to an old print, the illustration above fairly depicts that historic craft. Unfortunately, the vessel got aground before coming into action

and fell into the hands of the enemy. It was held by Alexander of Parma to the end of the siege as a curiosity, but was never employed by either side in any action.

EVER since the introduction of twin screws for steamship propulsion, the question as to which way the screws should turn for best efficiency has come up periodically, but was never definitely answered. A few months ago, however, Mr. R. E. Froude presented a paper before the Institution of Naval Architects, in which he gave the results of a series of experiments which had been made specially to throw light on this subject, and we are now assured that it makes practically no difference whether the screws turn inwards or outwards. Strictly speaking, inward turning shows, on an average, an advantage over outward turning; but the percentages of greater efficiency are all very small, and, therefore, practically negligible. Mr. Froude, in his paper, explained that the making of the experiments was more particularly agitated by the fact that a few years ago, in the design of certain British ships of war, it was deemed desirable, for convenience in arrangement of starting platforms in the engine rooms, to have the screws turn inwards when going ahead, instead of outwards, as usual,—in other words, that the starboard screw should be left-handed and the port screw right-handed, instead of *vice versa*. Model experiments were, therefore, made at Haslar to determine whether this arrangement was likely to be detrimental to efficiency, and the results showed that, in the models of the particular ships in question, the arrangement was favourable to efficiency rather than otherwise. Afterwards, whenever proposed designs of new ships were tested in model at Haslar, with propellers, it being at that stage generally not decided which way the screws were to turn, it became the practice to try both directions of turning in nearly all cases. A considerable collection of results of model experiments on the comparative efficiency of the two directions of turning was thus accumulated, and from these Mr. Froude gathered the conclusion previously noted, which at last disposes definitely of the whole matter.

TORPEDO boats and torpedo boat destroyers are much in evidence just now. The new naval appropriation bill in the United States calls for sixteen "destroyers" of about four hundred tons displacement, and twelve 150-ton torpedo boats. From this it is evident that American ship-builders will have, at one jump, to turn out the largest and most powerful "destroyer" that has ever been attempted, and the United States government seems inclined to add still further to the difficulties by introducing anew the question of armour for the machinery spaces. It has hitherto never seemed advisable to add the weight of armour to the vessels, as it could be done only at the sacrifice of speed, and the small protection afforded by such armour, moreover, has generally been considered of very little value, especially when operating against big ships. Speed, rather, has been the desideratum, and to attain this in the highest degree, weight has been reduced all around,—in the hulls, in the engines and in the boilers. Adding it now in the shape of armour would seem to be almost like going back to the first steps in torpedo boat development.

WHAT is said to have been, properly speaking, the first British man-of-war is described in *The Mechanic's Magazine*, of 1823. It was named *Henry Grace de Dieu*, more commonly known as *Great Harry*, and was built by King Henry VIII. in 1514 at an expense of about £14,000. It was of 1000 tons burden, was manned by 349 soldiers, 301 marines, and 50 gunners, and carried 19 brass and 103 iron pieces of ordnance. The vessel had four masts, and port-holes on both decks and in other places. Before the period of her construction the ordnance pieces of a war vessel were always placed above

deck, but a French shipbuilder of Brest, Descharges by name, having about that time invented "port-holes," this ship was the first vessel to adopt them. The name of the ship is supposed to have been changed in the reign of Edward VI. to *The Edward*, which, in 1552, was reported to be still "in good case to serve," and ordered "to be grounded and caulked once a year, to keep it tight." No subsequent notice of this ship is to be met with in the British naval annals, but it is supposed to have been burned at Woolwich, August 27, 1553.

APROPOS of the matter of ventilation in warships it was very properly pointed out some time ago in *The Engineer*, of London, that almost every modern naval vessel is disfigured by a crowd of cowls and windsails. In some cases these cowls actually obscure the view from the conning tower. What would become of these things when the ship goes into action? One gallant officer to whom the question was put said that the first thing he would do was heave them overboard. They are at once disfiguring and needless. They take up a surprising amount of deck room that can be very badly spared, and they are continuously in the way. They are simply elaborated survivals of the period when the windsail was the only method known of forcing air into the lower portions of a ship,—a thing necessary to be done even in fine weather, when all the ports on the main and lower decks were open. In Nelson's days there were no ships' fans, and if there had been, there was no way of using them. In the gun foundries very crude things, driven by horses, were used to supply blast to the cuplas. When the fan was fitted on board ship, it did not take the place of the windsail, but was added to it; and it has been urged that as the fan would be shot away in action, the windsail is a necessary evil. But there is no reason at all why the fan should be shot away, or why it should run any risk whatever, at least of destruction by an enemy's guns. The fan ought to be placed where room can be found for it low down in the ship—far below the water line—and driven by electricity.

THE use of electricity in this way enables us to do what could not be accomplished before. We can place our fan where we like; the distribution of the air subsequently is but an affair of wind trunks. Until electricity was available, each fan had to be provided with its own steam engine, and to say nothing of the circumstance that the engine took up a good deal of space, there were dozens of situations quite suitable for a fan alone, but most unfit for a steam engine. An electrically-driven horizontal fan, with its motor, can be got into the thickness of a deck with its beams, if need be; and, indeed, small fans are used now to excellent purpose in various places on board ship. But a proper system of ventilation would dispense entirely with wind cowls, or other protuberances above the decks. Trunks would lead the air to powerful fans deep in the ship, and trunks would lead the air from the fans to the place where it was wanted. It would not be an immensely difficult matter to secure a *plenum* in almost every part of a ship. Fans are now used in abundance on board men-of-war; but old prejudices still cling, and not so much is made of the fans as might be.

PHOTO BY MERRITT, WASHINGTON.

David Ammen
Rear Admiral U. S. N.

THE DESIGNER OF THE U. S. RAM "KATAHDIN."

(See page 267.)

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VOL. XIV. JULY, 1898 No. 3

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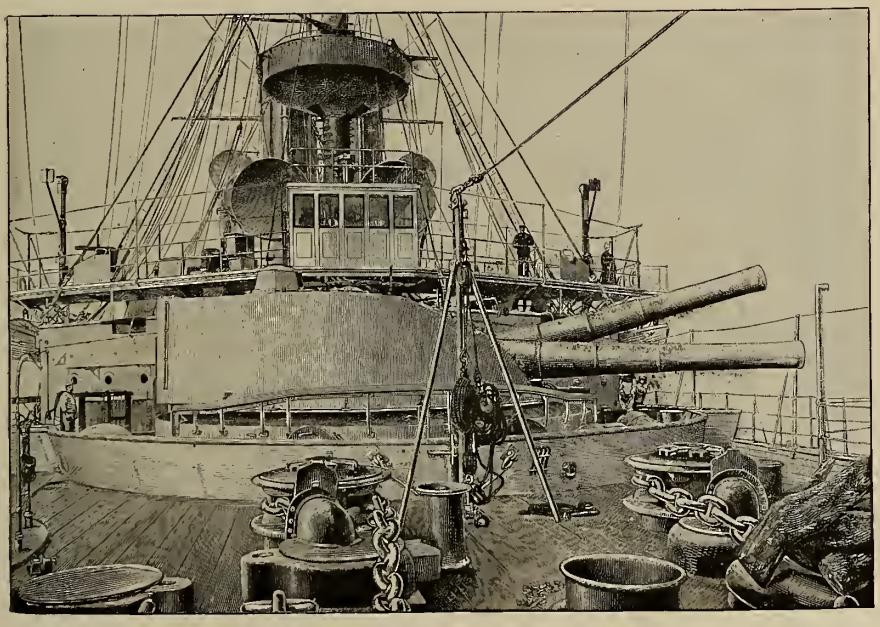
PROTECTION OF BRITISH COMMERCE IN WAR TIME.

By Rear-Admiral Lord Charles Beresford, C. B., M. P



THE FORWARD BARBETTE OF H. M. S. "BARFLEUR."

THE question of the protection of commerce in time of war, as applied to the British Empire, is a very much bigger one than is at first sight apparent, and involves far more careful thought and organisation beforehand than most people who talk and write about it imagine. There is first the question of what we have to defend. It is not merely the welfare of British trade and commerce, representing, as some suppose, the possible loss of so much money, which is at stake. There is the still more vital question of defending British food supplies and feeding the people. It is a matter of avoiding possible starvation. In war between Great Britain and any

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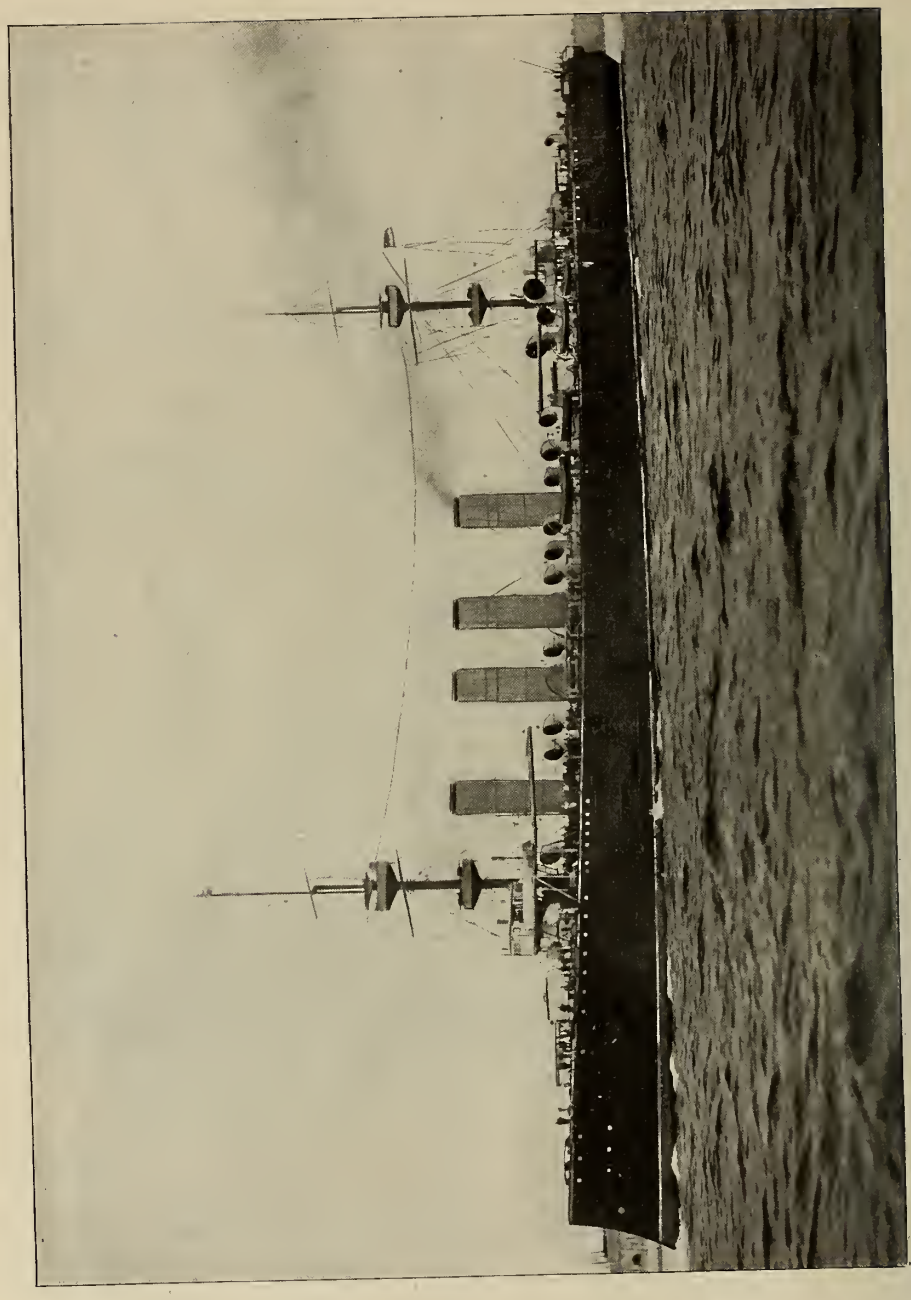

H. M. CRUISER "TERRIBLE." DISPLACEMENT 14,000 TONS. SPEED, 22½ KNOTS. BELLEVILLE BOILERS.

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other power or combination of powers, unless Great Britain can secure the certain and punctual delivery of both food stuffs and raw material, the country, and the working classes particularly, would suffer first from want of food, and secondly from want of wages, as, failing the raw material, almost all industries would be affected directly or indirectly, and the interdependence of the various forms of labour would be at once recognised.

Before going into the question of the probabilities of attack and the means of defense, it would be well to ascertain what Great Britain has to defend. British trade, represented by imports and exports, is valued in round figures at £800,000,000 a year, but this does not represent the sea-borne commerce of the British Empire. If we add to it the value of mercantile shipping, the British coal in ships' bunkers, and the bullion and securities passing to and fro, we find by the most careful calculations that the sea-borne commerce of the British Empire may be reckoned at 2000 millions sterling. This is the money value, and it represents exactly two-thirds of the total maritime interests of the whole world.

In 1801 the population of the United Kingdom was only 16 millions, and only 1 in 23 was fed on sea-borne food. To-day, with a population of nearly 40 millions, over one-half depend on sea-borne food, *i. e.*, 1 in 2, instead of 1 in 23, and more than three-fourths of that population are dependent upon the steady and continuous supply of raw material for their daily employment. Great Britain imports £20,000,000 of foreign wheat and 8½ millions sterling of foreign wheat and flour every year, taking normal prices, besides 11 millions sterling of other cereals.

These figures exclude 2 millions sterling of wheat, about a million sterling of flour, and three-quarters of a million sterling of other cereals imported from India and British colonies. Butter, eggs, cheese, lard, beef, bacon and hams, mutton, pork, and live cattle, fruits and vegetables, are imported in

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DIVERS ON THE BRITISH CRUISER "POWERFUL," GETTING READY FOR WORK.

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ON THE QUARTER DECK OF H. M. S. "CHARYBDIS."

equally large quantities. As a nation, we stand unique in the history of the world for our entire and utter dependence on outside sources for the means of feeding our densely populated country. Our commerce is both the source of our wealth, and the origin of our weakness. We are vulnerable in the very part of our system from which our greatness springs.

There are one or two points that I wish to drive home on this subject before going further. The first is that it must be noticed that the great increase of our population, and the greater increase of our dependence on sea-borne food and raw material, has all come since our last great naval war. It is a startling fact that we have no data of any sort, description, or kind upon which to base our ideas of the protection of commerce in the next great naval war. The conditions under which we lived at the beginning of the century, and the conditions now, are so changed that we can argue only in the dark on the probable effects of war.

The second point is not less important. It is that in the great warlike period of the end of the last and the beginning of the present century we lost (*vide* Norman's "Corsairs of France") 10,871 British vessels, captured between 1793 and 1815. This was during the period of our great naval triumphs, and represented the losses of a successful war. It lends a strength to a very old contention of mine, viz., that the price of victory may be a very dear one to a country like this, and that the losses inseparable from a successful campaign will be enormous.

The third point is that the naval strength of other powers is stronger relatively to our own than it was in our last great naval war, and certainly the prospects of a strong coalition against us are not less than they were in the Nelson period.

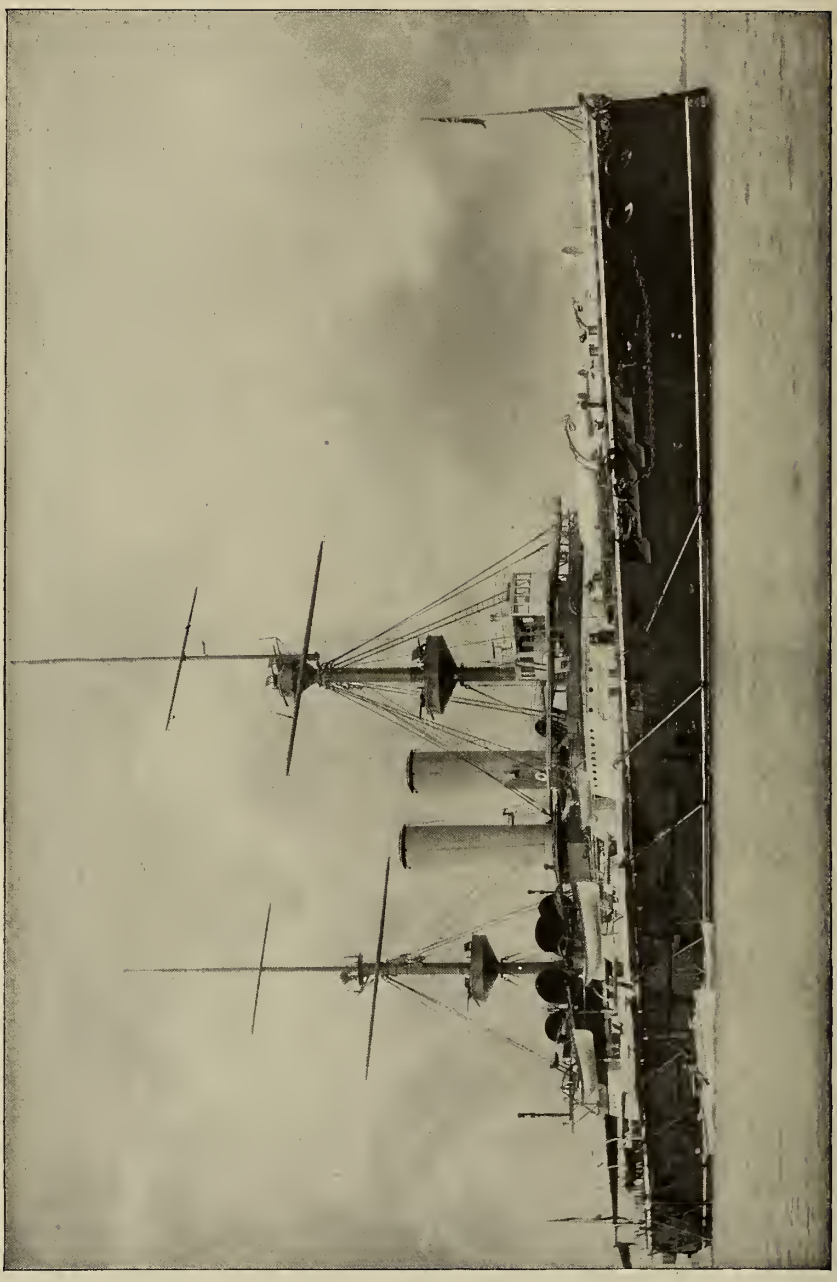
Having studied what we have to defend, the dependence of our population for wages and food on our commerce, and the historical teachings of the past as to the dangers of preserving intact larger interests, our next steps are to consider the possible line of attack, and the strategy which is to meet and successfully evade or repulse such attack, if our mercantile interests are not to be ruined in war.

It is well to remember that while the chief aim of our military shipping will be either to blockade the enemy in his own ports, or to induce him to come out, and then to capture or destroy him at sea whenever or wherever found, there is to be considered the larger duty of protecting commerce by direct means. It will not be sufficient for the navy to blockade and fight the enemy, because if this alone were done the damage which might be inflicted on our commerce by one or two cruisers which got out, on to the trade routes, would be simply incalculable. The danger from cruiser attack in the blue water, and of torpedo attack in the narrow seas, are the two great elements of danger which we have to face in defending commerce.

With regard to the narrow seas, the French have ten torpedo stations between Dunkirk and Morlaix. There is no point between the south of England and the north of France that would be beyond the "radius of action" of torpedo-boats from one of these stations. On the west of France there are eight torpedo stations of a similar character, in railway communication with those on the north, and provided with proper apparatus for carrying the torpedo-boats.

To the east of Gibraltar the French have sixteen torpedo stations, four in

A SIX-INCH RAPID-FIRE GUN.



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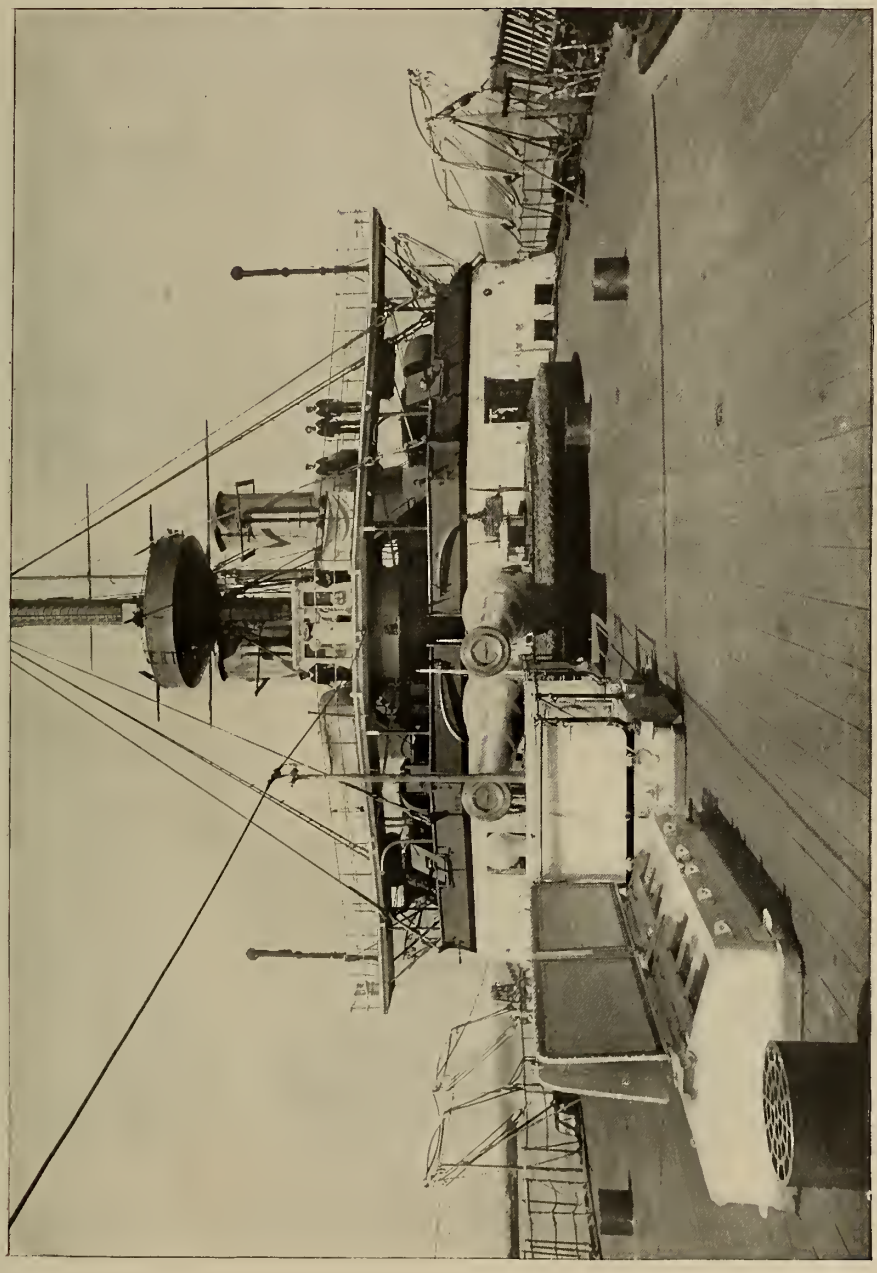
THE BRITISH BATTLE SHIP "ROYAL SOVEREIGN." TWIN SCREWS. DISPLACEMENT, 14,260 TONS. I. H. P., 13,312. SPEED, 18 KNOTS.



A DECK VIEW ON H. M. S. "ROYAL SOVEREIGN."

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A GROUP OF DIVERS ON H. M. S. "MAGNIFICENT."

Algiers and Tunis, four on the coast of Corsica, and eight on the southeast coast of France, their radius of action extending from Gibraltar to Malta. Another noteworthy point is that the French torpedo stations are properly organised and equipped. Ours are merely adjuncts of busy dockyards, and lack that careful attention to details which characterises the French stations. These have all sorts of appliances, machinery, spare gear, and a properly trained personnel.

I am aware that the objection has been raised that international rules would scarcely allow of a torpedo-boat attack upon the mercantile marine during war. International rules, which may be observed when insignificant powers quarrel and there are all the great powers to look on, and perhaps to interfere, are likely to be much more elastic when the greatest naval power—ourselves—is opposed to a coalition of two or more of the next greatest powers. In other words, there is no possible chance of securing the recognition of so-called international rules and usages in warfare unless the parties to the quarrel are overawed by a possible combination stronger than themselves, or the fear of reprisals acts as a deterrent. Apart from this, the torpedo-boat argument is very weak, in my opinion, because if it is permissible for a cruiser to destroy commerce by means of torpedoes,—a right which no one seeks to deny,—it is on the face of it hardly likely that the right could be denied to the torpedo-boat pure and simple.

With regard to the second point, as to cruiser attack in blue waters, a foreign programme of strategy which lies before me as I write, points out that "to have Great Britain at our mercy, it suffices to starve her by intercepting and hitting her enormous mercantile fleet which carries the treasures of the world; it suffices to starve her by stopping the packet boats that supply corn from foreign lands. These long files of cargo boats generally take the same course, routes that are known to all navigators, each of these ships recognises, in its turn, certain capes, that serve as landmarks on their way. It is, therefore, easy to overtake them on their usual route or at their landing-place."

This plan of attack will undoubtedly be adopted by any power opposed to

us, and it will be the damage done before we are ready that will be the worst. Shippers are very nervous people, and the frightful losses which our mercantile marine is, at present, likely to suffer upon the outbreak of war, would send up insurance rates to a prohibitive figure, deter shippers from sending cargoes afloat until our navy had achieved some striking success, and these two items would so operate as to cause an immediate and alarming rise of prices in this country directly war was declared.

It will be seen, therefore, that the solution of the problem how to meet these dangers lies entirely in the question of adequate organisation before there is any probability of war. A definite system of keeping open the line of communication must be laid down. The Admiralty part of the plans for the mercantile marine in time of war ought to be cut, dried, and pigeon-holed, ready for use. To the best of my knowledge and belief, there are no such plans, except of the most elementary character. There were none in 1888, and it is unlikely they have been made since. The dangers are undoubted. Will Great Britain in the face of these dangers remain unprepared?

A great many people underestimate the difficulties of the position, owing to the great apparent superiority of this country in point of numbers of cruisers; but it must be recollected that Great Britain will require a great many more cruisers in proportion. In connection with the military shipping we have a much larger fleet than any other nation, and a greater number of cruisers will be required to act as scouts and linking ships. Besides that, we want cruisers all over the world to attack and destroy

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GREAT GUNS ON H. M. S. "ROYAL SOVEREIGN."

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THE BRITISH TWIN-SCREW CRUISER "BLENHEIM." BUILT BY THE THAMES IRON WORKS & SHIPBUILDING CO., LTD., LONDON.
DISPLACEMENT, 9000 TONS. I. H. P., 21,411. SPEED, 21½ KNOTS.

the enemy's cruisers, and to defend our commerce.

The enemy will attack our mercantile marine with cruisers, auxiliary cruisers, etc., and not with battle-ships. The duties of our battle-ships will be to look after the battle fleets of the enemy, and therefore we must meet like with like, and cruisers must be detached to all parts to defend the trade routes, or, in other words, to keep open the line of communication. The line of communication in war time is everything, whether it is the communication between fleets, the commercial routes, or signalling. Lines of communication in war can be properly provided for only in time of peace.

Without careful organisation beforehand there will be a most hopeless state routes by the fewest possible number of vessels, and of making it much more difficult for stray cruisers or privateers to prey upon our commerce undetected.

The advantages of wireless telegraphy, utilised in connection with this system, are very obvious. This leads to the consideration of another very serious aspect of the question, and this is the protection of cables and the communication between ships of the fleet and ships of the mercantile marine. There is no doubt that soon after the outbreak of war, a determined effort would be made to cut our cables, probably at a point where the deep sea cable joins the shore end. It is of the highest importance, not only to our navy, but to the commercial community, that this line of communication should be maintained intact. We ought to have properly equipped cable ships, ready to start as soon as war was declared, to pick up the cables at the point mentioned and to relay them to an unknown point.

All of the present cable routes are well known to all possible enemies, but the risks of destruction are greater about three miles from our coasts than anywhere else, and if we picked up the cables and relaid light ends, we should seriously disconcert the enemy. The system of communicating between ships of the navy and ships of the mercantile marine is very bad. A great many vessels could be saved by speaking them and informing them of the outbreak of hostilities, and what to do; but the present code is very old, and apparently very little used. I can only give my own experience when returning to England in H. M. S. *Undaunted*. I signalled thirty-two vessels of the mercantile marine, but could get answers only from seven. It is imperative that ships of the mercantile marine should, in their own interests, be able to read and reply to signals promptly.

At present the fastest vessels of the mercantile marine are retained as auxiliary cruisers at the disposal of the government in time of war. In all cases of ships subsidised by government, only Royal Naval Reserve crews should be allowed to be carried. Some of the vessel's armament should also be carried, so that she could speedily be transformed for purposes of defense or attack. The crews should practice firing at intervals on their own ships. The *Teutonic*, which was fitted out with her guns on board to take part in the naval review, was not allowed any ammunition, so that, except for display, her fitting out was useless to her officers and crew.

Every encouragement should be given to British shipowners to build fast ships, and vessels engaged in the food supply of the country which could show a clean pair of heels to any pursuer would be invaluable in time of war. An idea which emanates from Canada is for the subsidy of a Canadian line of vessels of great speed specially built for the conveyance of food supplies.

The coal supply of the pivot ships engaged in protecting the trade route has been mentioned. The colliers referred to would have to be built. It is not sufficient for us to possess coaling stations to which vessels would be compelled to return very often. We ought also to possess a properly organised fleet of government colliers, ammunition ships, repairing ships and cable ships, to accompany fleets. The collier should be in direct communication with the coal mines or coaling base, and so save the expense of the present system. This would also save vessels being compelled

to return to their coaling bases too often, a duty which could be performed by the colliers.

At present, the coal is shifted from the mine to train; from the train to a coal wharf; from the wharf to a lighter; and from the lighter to the ship. The steam collier should be the sole go-between, and should be properly fitted for coaling at sea. The present lighters are all of different lengths and different height of freeboard, and so the appliances for coaling can be only extemporary and inconvenient. Coal is most important, and the "life" of the patrol ships on trade routes, *i. e.*, their coal endurance without the necessity of returning to port, would be increased enormously by a system of proper steam colliers, meeting them at certain points. These colliers should have been built this year out of the unappropriated surplus of £800,000 of last year's balance on new construction. At the time of writing (May 25) the First Lord complains of not being able to make up more than £1,400,000 of the dangerous deficiencies in our ship-building programme, owing to a want of armour. Then why not spend the money on these useful and necessary auxiliaries, like steam colliers, which must be provided if our fleet is to do its duty of maintaining our commercial interests at sea?

These questions are very serious ones, and must be properly thought out before hostilities commence. Even if our trade is diverted to less exposed ports in time of war, we shall have to deal with the problem of its distribution. Half a million of London's population finds employment in the receiving, storing, and forwarding to all parts of food supplies. If these be interrupted, these people will be thrown out of employment unless their special knowledge and work is utilised elsewhere.

The war between the United States and Spain will not be an unmixed evil if it brings nearer home to us the moral of necessary organisation for the protection of commerce in time of war; and the war, and the various other causes which have sent up the price of wheat ought to teach us a lesson of which we are urgently in need. I have always held that if we go to war, and, through lack of forethought and organisation, bring about a stoppage of food and raw material, it is possible that the working classes will turn on the so-called governing classes, and will hold them responsible for their miseries.

A hungry British population would be very difficult to manage, and more so than those of foreign countries. Nor would it mend matters to call upon their patriotism in such a crisis. The growth of education would make a difference to the old order of things. Then, the men would buckle on cutlasses and go out to fight if there was any one to lead them. Now, it is more than possible that they would say, "You have brought us into this miserable condition, and now you ask us to go out and be shot."

A terrible responsibility rests on the men who are paid in time of peace to organise and prepare for the protection of the national interests in time of war, and a terrible retribution will be exacted from them by the nation if it is found that they have failed in their duty.

THE RAM IN MODERN WAR FLEETS.

By William Ledyard Cathcart.

(*Concluded from page 136.*)

IN THE UNITED STATES FLEET.

The deep impression made on the popular mind in America, both North and South, by the ramming of the *Cumberland*, which has been previously mentioned, was shown during the Civil War by the fact that, thereafter, every Confederate ironclad was known as a ram, although that feature of the *Merrimac's* equipment was, with due warning, perhaps, the least to be feared.

Thus, we have the "ram" *Atlanta*, taken by the gallant John Rodgers in a fifteen minutes' action; the "ram" *Albemarle*, torpedoed by Lieutenant Cushing; the "ram" *Arkansas*, which figured briefly on the Yazoo and the Mississippi; the "rams" *Chicora* and *Palmetto State*, which made a dashing raid from blockaded Charleston; and, most formidable of all, the "ram" *Tennessee*, whose capture crowned Farragut's victory in Mobile Bay. All of these vessels were primarily ironclads and battleships, but as "rams" the country knew them.

In the opening of the Mississippi River by Farragut from the south, and Foote and Davis from the north, attacks by ramming were a not infrequent incident in action. The Confederate *Manassas* was much in evidence during the operations below New Orleans. Originally a twin-screw, sea-going tug, she had been cut down, covered with a curved shell of timber, plated with 1-inch railroad iron, and fitted with a wooden spur. This much overrated "pigmy monster" charged frequently and struck several vessels, with little success, although she pierced, in one assault, the planking of the *Brooklyn*. Her speed was but 5 knots.

After the passage of Forts Jackson and St. Philip, the Federal *Varuna*, commanded by the gallant Boggs, was rammed several times by the Confederates *Governor Moore* and *Stonewall Jackson*. She had already been handled most severely, and, after this attack, filled rapidly and was run ashore; but her guns were fired until submerged. Of the coolness and courage shown to the last on the maimed and battered ship, Captain Bailey, the divisional officer, said:—

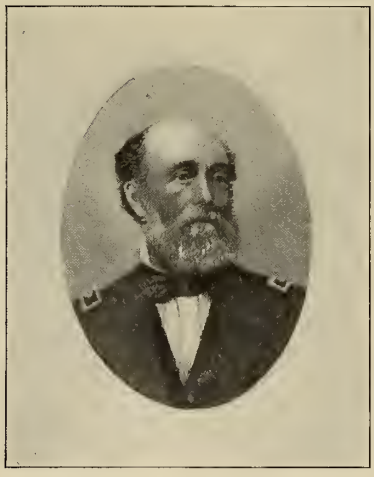
"I saw Boggs bravely fighting, his guns level with the water, as his vessel gradually sunk."

On the Upper Mississippi, the use of rams by the Confederates brought to the front on the Federal side one of the striking characters of that time—Colonel Charles Ellet, a distinguished civil engineer, who, during the Crimean War, had submitted plans of a ram to the Russian Emperor. Failing to find recognition then, Ellet clung to his conception, and, when war broke out in the United States, advocated with persistence the building of a fleet of rams.

Commissioned finally as Colonel of Engineers, he was sent to the West and purchased for the United States government nine river steamers and tug-boats. The bows of these he strengthened with heavy timbers and sheathed with iron bars, protecting their machinery with oaken bulkheads and their pilot-houses

with thin plating. Four of them were side-wheel craft; none carried ordnance.

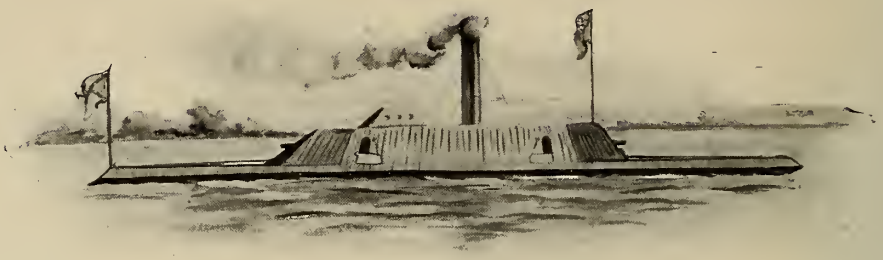
Ellet's first combat was his last. Near Memphis, on the Mississippi, June 5, 1862, the Federal fleet was attacked by eight rams. Ellet, in the *Queen of the West*, was in the rear; but, crowding on steam, he swept to the front and charged the nearest Confederate, the *General Lovell*, so fatally that she sank almost at once. While entangled, the *Queen* was rammed near the pilot-house by one of the hostile steamers; and, losing one wheel, was run ashore. The only injured man on her was Ellet,



CAPT. C. S. BOGGS, U. S. N.

who was struck in the knee-cap by a bullet. From the effects of the wound he died on June 21—sixteen days after the fulfillment of the ambition of his later years.

One of the most formidable of the Confederate vessels was the *Albemarle*, whose story throughout seems less like reality than romance. Although a case-



THE CONFEDERATE RAM "ALBEMARLE."

mated ship (122 feet long, 45 feet beam, 8 feet draught) with 4 inches of armour, two 100-pounder rifles, and a massive ram-bow, she was built in the woods, of unseasoned timber, in a place and at a time when iron seemed worth almost its weight in gold, so great was its scarcity.

On April 18, 1864, she steamed from her dock down the Roanoke river in North Carolina, and, at dawn, met two Federal vessels, the *Miami*, a side-wheel gunboat, and the *Southfield*, a converted ferryboat. Both carried heavy batteries, and they were lashed together and abreast. The ironclad rammed the *Southfield*, sinking her. While locked with her, Lieutenant Commander Flusser, of the *Miami*, fired, at point-blank range against her mailed side, a 9-inch shell, the fragments of which, rebounding, killed him. The *Miami*, whose guns were helpless against her armour, then retreated.

On May 5 the ram again appeared, confronting a fresh Federal force. The marked feature of this action was the heroic charge of the *Sassacus*, a double-ended side-wheeler, whose captain was Commander (now Admiral) Roe, and whose navigator was Lieutenant Boutelle, now, and for years, a distinguished member from the State of

Maine of the United States House of Representatives.

"Can you strike her?" shouted Roe.

"Yes," answered Boutelle.

"Then, go for her!"

And with fiery determination, the weak bow of the gunboat, driven at utmost speed, was forced several feet into the timber belting of the ram.

Locked as they were, both ships steamed ahead, swinging until their broadsides bore. Then a shot pierced one boiler of the *Sassacus*, scalding Chief Engineer Hobby and 14 of his men. The steam clothed in a cloud the injured ship, and, for a moment, confusion reigned. Then, once again, the watching fleet heard the roar, and, through the mist, saw the faint flash, of her guns. The chief engineer, with unflinching devotion—wounded as he was—had aided in hauling fires from the remaining boiler to stop the generation of steam and kept the engines running, until, after 13 minutes of contact, the crippled double-ender dropped clear. The ram, however, remained unconquered and retired in safety, despite the fierce assault of the rest of the fleet.

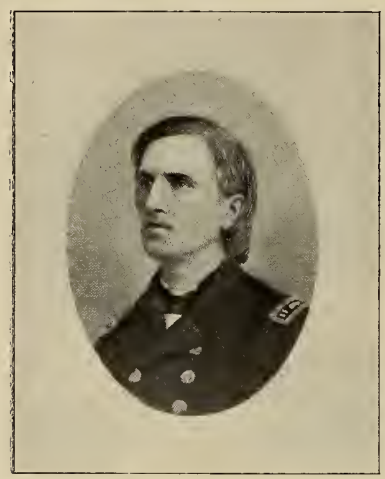
The story of the destruction of the *Albemarle*, on a stormy night in late October, is a part of the torpedo's history, rather than that of the ram. There is no more thrilling tale in warfare than that of Cushing, young in years, but old in judgment and in daring, stealing up the Roanoke in his light launch, with but fourteen officers and men; finding the ram's crew slumbering, with only the dog on watch; driving his boat over the encircling boom of logs; exploding his torpedo against her side; and, with his work well done, diving into the stream through a hail of canister.

In its conception and execution, there is, throughout American naval history, no parallel to this, unless it be the burning of the *Philadelphia*, in the harbour of Tripoli, by the young Decatur, that paladin of fighters on the sea—of whose deed, in this, Lord Nelson, ever generous, said:—"It was the most bold and daring act of all the ages."

THE "ALBEMARLE" RAMMING THE "SOUTHFIELD."

In the engagements of this war on distant seas, the ram, positively or negatively, seems to have been a factor of importance. In the issue of this magazine for April, 1897, the action was described in the harbour of Bahia, Brazil, between the Confederate cruiser *Florida* and the United States sloop-of-war *Wachusett*, and there was set forth the marked gallantry in this of Commodore Melville, the present Engineer-in-Chief of the United States Navy, who, though, then, but a lad in years, not

only advocated successfully the use of the ram, but, at the risk of his life, boarded the Confederate to note her vital points; and who later, when the blow was struck, faced, practically alone,



LIEUT. W. B. CUSHING, U. S. N.

its possible perils in the engine room. The ram's work there was swift and sure.

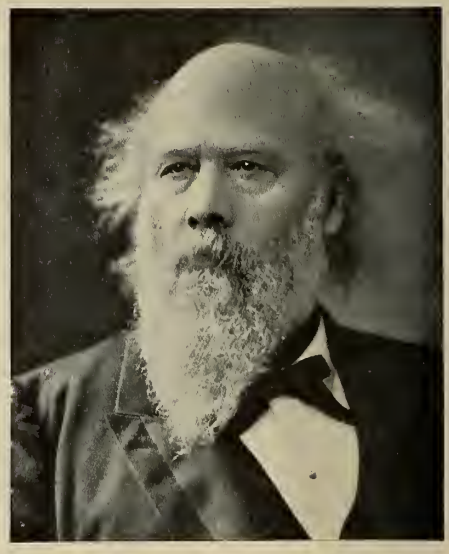
The conflict between the Federal *Kearsarge* and the Confederate *Alabama* was fought, off Cherbourg, France, over a spiral course of seven turns. In discussing the plan of this action, Lieutenant Meigs, U. S. N., has said:—

"If she (*Kearsarge*) had steered ahead of her (*Alabama*), a running, parallel fight might have occurred. * * * As each ship was trying to get into the other's wake, they moved in the circumference of a common circle. * * * The reason that the *Kearsarge* did not steer ahead of the *Alabama* was, doubtless, because she feared her ram."

It is, however, when we turn to the fight which Farragut described as the hardest of his life "since the days of the old *Essex*,"—that of Mobile Bay, August 5, 1864,—that we find wooden ships hurled as rams against an ironclad with a gallantry and determination which make the scene one of the noblest battle-pictures of all history. The task set the admiral, in the forcing of this harbour, was large and varied. If successful against guns ashore and torpedoes afloat, he had yet to face a squadron, chief among whose ships was the ram *Tennessee*.

She was a much-improved *Merrimac*, built of wood, and was 209 feet long, 48 feet beam, and 14 feet draught. Her armour was 6 inches thick forward and 5 inches elsewhere. She mounted 6 Brooke rifles,—two 110-pounders and four 95-pounders. A most valuable feature of her structure was the "knuckle," a continuation of the inclined casemate below the water-line to meet an opposite inclination from the hull, this forming a wedge-shaped and armoured projection, on which rams of wood would strike in vain. Her engines were somewhat weak and her rudder chains were exposed; but, otherwise, she was a most formidable vessel for her time.

From half-past five in the morning, Farragut's fleet had been under way. His fourteen wooden vessels and four



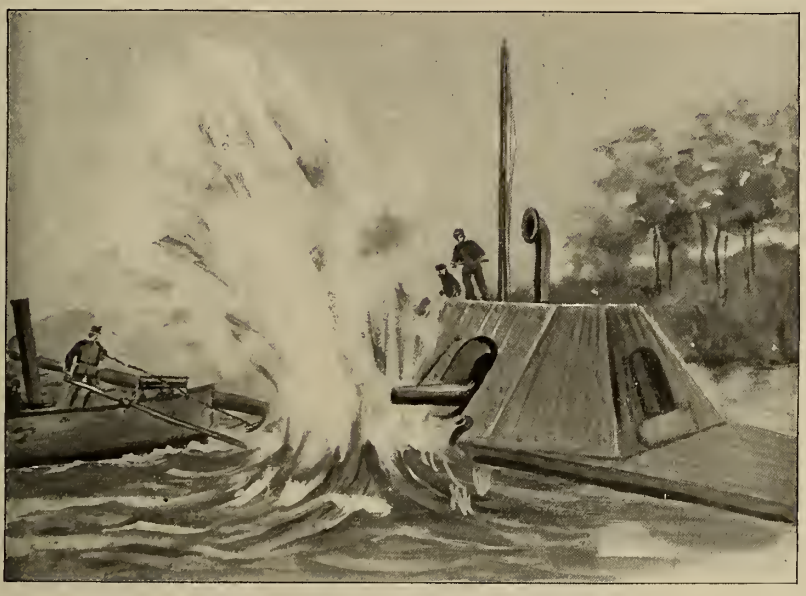
COMMODORE GEORGE W. MELVILLE, U. S. N.

monitors had steamed through a channel but 300 feet wide between a cross line of torpedoes and Fort Morgan, with its furious fire, while the batteries of the

Confederate gunboats ahead had raked them in their slow advance. During that passage, he had seen, from his station in the shrouds, the *Tecumseh*, one of his most powerful monitors, strike a torpedo and sink like a sounding lead.

As his ships, appalled, halted in momentary confusion, the Admiral had sworn his historic oath, and had dashed outside the column to its head, passing over in his course the line of torpedoes which had been so much dreaded, but which were not fated to sink him. He had met the *Tennessee* and his ship, the *Hartford*, had been hulled by her, as turned to meet her, but, flinching, sheered off and Farragut's unswerving blow glanced from her iron side. The *Lackawanna*, sweeping around to repeat her stroke, ran by accident into the flagship. For a moment, in the confusion and shock, it was thought that Farragut was lost, and a great cry, "Save the Admiral!" rose from the *Hartford's* decks.

Like a sullen mammoth, the ironclad faced the fleet. She was fought with the courage of despair. The ramming blows of the wooden ships hurt her but little, and their broadsides rebounded in

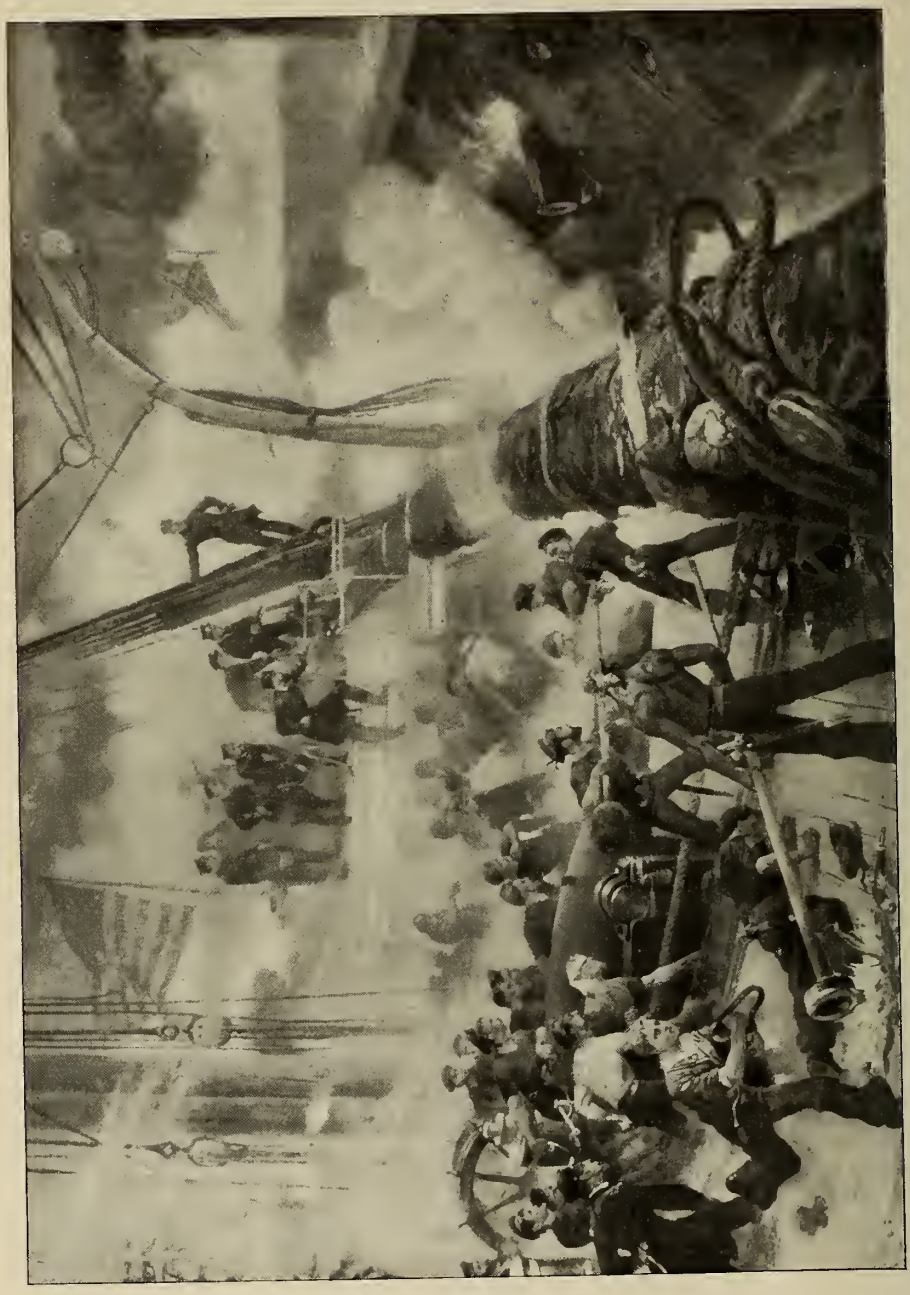


LIEUT. CUSHING BLOWING UP THE "ALBEMARLE."

the ram passed slowly down the Federal line to safety beneath the guns of Morgan. And now, at half-past eight, the forts and torpedoes lay behind his force, the ram had gone to cover, and there seemed time for a breathing spell.

But his fleet had little rest. Shortly before nine, the ram steamed out for further battle. The monitors were yet at a distance and Farragut signalled his wooden ships to run her down. The *Monongahela* struck first—fairly, at full speed, and abeam. The *Lackawanna* came next, with a blow on the port quarter, so heavy that the ram heeled. Then the *Hartford* charged. The *Tennessee* ragments from her armour; while, as opportunity served, she sent murderous shell into their crowded decks. The coming of the slow but powerful monitors made a sudden change.

Hugging her close, their heavy ordnance racked her armour, splintered its backing, shot away her rudder chains, and knocked over her smoke pipe. Battered and helpless, after an action lasting, in all, more than an hour, the ram showed the white flag. It was fully time. The Confederate admiral was wounded, the casemate was choked with gases from the shattered smoke pipe, one gun was dis-



FROM A PAINTING BY OVEREND.

THE UNITED STATES FLAGSHIP "HARTFORD" IN CONFLICT WITH THE CONFEDERATE RAM "TENNESSEE" AT THE BATTLE OF MOBILE BAY DURING THE AMERICAN CIVIL WAR, AUGUST 5, 1864.

abled, several port-shutters were jammed, and the steering gear was useless.

This was, in effect, Farragut's last fight. He was no more afloat in action, excepting at the reduction of Fort Morgan on August 21 and 22,—an easy task for his force. As a lad of twelve, he had served on the shattered *Essex* when she faced the *Phœbe* and *Cherub* in Valparaiso Bay. He met the bitterness of defeat then; but his career of warfare ended in victory on the day, when, aloft in the shrouds of the *Hartford*, his strong and kindly face blazing with the light of battle, he led his fleet at Mobile.

In Farragut's straightforward character, his unbending will, his calm and masterly skill, we see the traits of Blake, the greatest of Cromwell's "generals of the sea;" while the fiery ardour of Mobile, its instant daring and decision, cannot but recall the victor in that other final fight, whose memory lies so deep in England's heart.

As well it may. In the history of the sea, there is no more splendid figure than that of Nelson at Trafalgar, meeting the navies of France and Spain. The slender, wasted frame seems all too frail for its own ardour, and genius, and daring. The Admiral has reached the stint of life and is conscious, vaguely, of the end. On his breast there flash the bright insignia of his orders, which make him so fair a mark, but which no remonstrance can remove. "In honour, I gained them, and, in honour, I will die with them," he says.

That empty sleeve marks the missing right arm which he left at Santa Cruz. It was to that sightless eye, that, at Copenhagen, he levelled his glass, when he did not wish to see his chief's message of recall. Mast-head high, there streams out his last signal, which will be unforgotten while British ships shall float.

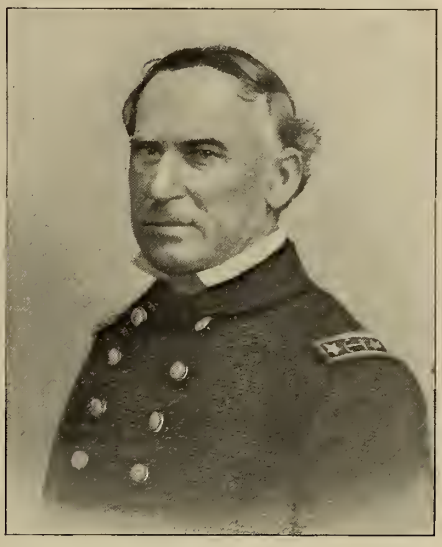
The desire of his eager heart is satisfied. As the ships grapple—with roaring cannonade, in smoke and flame—he meets, at last, that fleet of Villeneuve, which, through lagging months, over leagues of sea, he has sought so long in vain. Amid the thunders of that last fight, his unspoken thought of England, is the hail and farewell of the gladiators to the Cæsar:—"We, about to die, salute thee!"

Victory comes; but the notes of the *Io triumphe* seem, to the great Admiral, faint and far away. Shot down from the *Redoubtable*, the ship which he had twice spared, his life-tide swiftly ebbs.

"In the silence of the receding world, he hears the great waves breaking upon a farther shore."

His work was done; it was fitting that the end should come. The harvest, although early, was not premature. His biographer has said:—

"At each of the momentous crises,



D. G. Farragut

so far removed in time and place—at the Nile, at Copenhagen, at Trafalgar—as the unfolding drama of the age reveals to the onlooker the schemes of the arch planner, about to touch success, over against Napoleon, rises ever Nelson, and, as the latter, in the hour of victory, drops upon the stage, where he has played so chief a part, his task is seen to be accomplished, his triumph secured."

Since the American Civil War, there

have been built for the United States Navy but two vessels in whose design the ram was a primary factor,—the *Alarm* and the *Katahdin*. The former, begun under the Bureau of Ordnance in 1874, was an iron torpedo vessel of 800 tons displacement, 158 feet long, and 28 feet beam, with a large protruding ram whose base was an extension of the keel. She was never satisfactory, her career having consisted of long inaction, varied by brief experiments.

LORD NELSON IN HIS CABIN ON BOARD THE "VICTORY."

The *Katahdin* is a somewhat modified form of the type proposed by Rear Admiral Daniel Ammen, U. S. N. This distinguished officer has given much attention to the subject of coast-defence, to the strategical and tactical value of the ram therein, and to the design of vessels in which the ram shall be the only weapon of offence. Drawings of a type proposed by him were laid before the United States Naval Advisory Board, convened in 1881, which body recommended the construction of five rams, of 2000 tons displacement each, on the general design of that submitted. The Navy Department, also, at that time, recommended the building of one or more rams, but no appropriation was made.

Finally, on March 2, 1889, an act was passed for the construction of a harbour-defence ram of the general type approved by the board of 1881, this type being based on the Ammen design. Under this act the *Katahdin* was built, having been launched on February 4, 1893, by the Bath Iron Works, of Bath, Maine, U. S. A.

The Ammen ram is shown in perspective and section, on pages 224 and 227. In general form, she is cigar-shaped, her longitudinal midship section being approximately elliptical, and the transverse sections being composed of elliptical curves, full below, shallow above, and sponsoned out at the junction, thus giving good lines for the deflection of projectiles and presenting a sharp edge or "knuckle" for ripping and crushing, after having driven in the enemy's side. Her keel is elliptical, sloping upward to the downward droop of bow and stern—which keel-curvature gives great facility for turning, a primary essential of her type.

Her hull is built on the longitudinal girder and bracket system; it is excep-

tionally strong, and, in fact, is, as a whole, a well-constructed girder. There is a double bottom, with numerous compartments, by admitting water to which she can be sunk from normal draught to fighting level. The Ammen design called for a removable wrought steel ram-head, secured within a socket in the stem. As a substitute for the removable head, the Bureau of Construction, U. S. N., suggested a thimble, in the form of a gouge, wedged over the snout of the ram, which change met Admiral Ammen's approval; but neither the original design, nor the proposed substitute, was adopted. Her deck-armour tapers in thickness from the sponson inboard, and the latter is reinforced further by a belt of side-armour below.

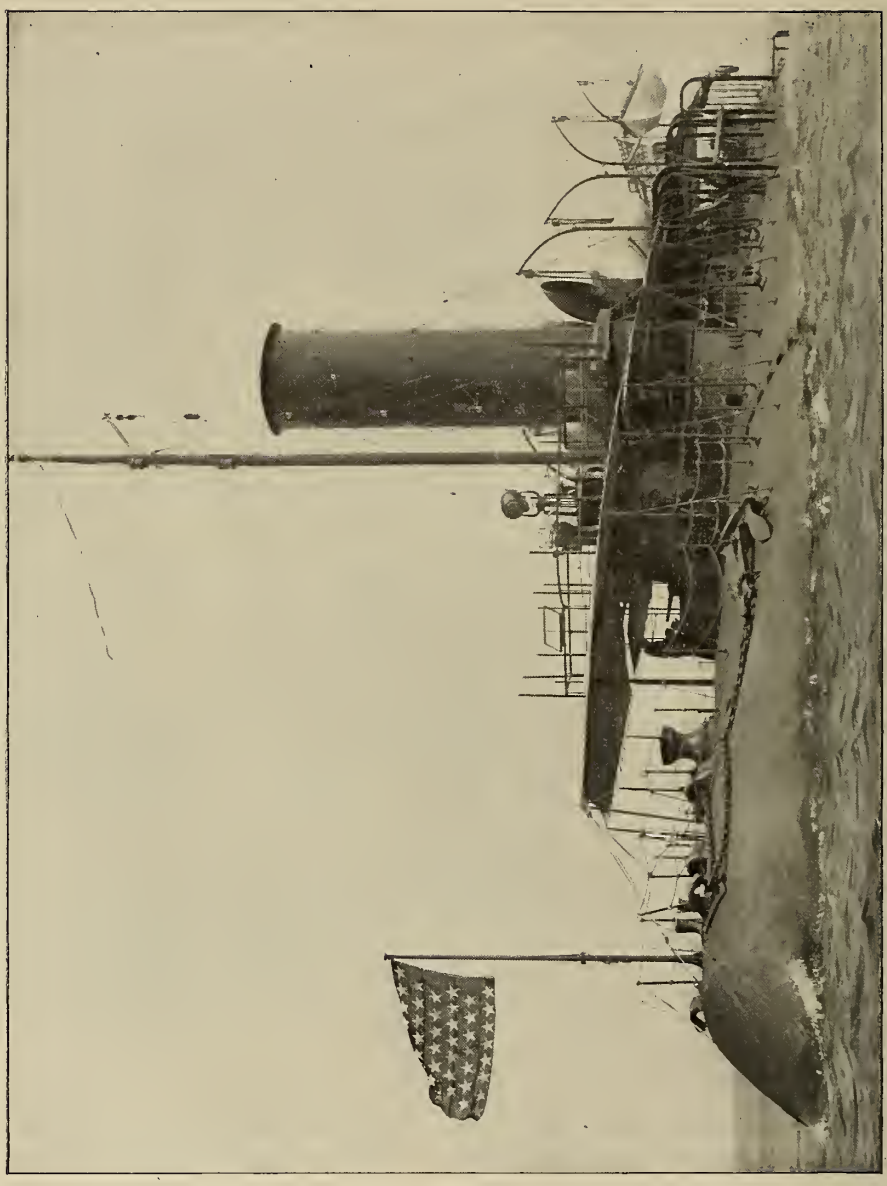
The design, of which the main features have been outlined above, has received not only official approval as set forth, but has been discussed favourably by many able officers of the United States Navy and by marine experts of high standing. The late Mr. John Lenthall, for years Chief Constructor of the United States Navy, aided in its early plans by suggestion and criticism. In 1881 Mr. J. Gibbons, president of the Pusey & Jones Shipbuilding Company, of Wilmington, Del., read a paper on "The Marine Ram" before the Washington branch of the United States Naval Institute, in which he endorsed, without reserve, the Ammen plans. Colonel Stevens—of the famous family of engineers, and the designer of the protected steamer *Naugatuck*—was so impressed with their value, that, in 1881, he addressed a communication to the Naval Committee of the United States House of Representatives, advising their development in vessels of five or six thousand tons.

The *Katahdin* is, in her main characteristics, a copy of the Ammen ram, excepting as to the bow section, which will be mentioned further on. She is a vessel of 2155 tons displacement, with extreme length and beam of 251 feet, and 43 feet 5 inches, respectively, and is built on the longitudinal and bracket system, with an inner bottom extending from the collision bulkhead to the stern. The longitudinals and girders supporting the deck are continuous, converging to the stem-casting and to the stern, the frames and beams being intercostal. In the double bottom and between the inner skin and deck-armour, there are altogether 102 compartments.

She is sunk to fighting trim by means of fourteen 8-inch Kingston valves, one in each transverse water-tight compartment of the double bottom. The only projections above the armoured deck are the conning tower, smoke pipe, ventilators, hatch-coamings, skid-beams for boats, and signal-mast. All armour is of nickel steel. The outside strake of deck-armour is 6 inches thick; the next tapers in thickness from 5½ to 2½ inches, the latter being the thickness of the remainder of the deck.

The side-armour is two strakes in depth, the upper 6 inches, and the lower 3 inches thick. The armament for defence against torpedo boat attack consists of four 6-pounder rapid-fire guns. For offence, the vessel relies solely on the ram, which should have been provided with a removable end, as in the Ammen design, or with the substitute before noted. The machinery consists of two horizontal triple expansion engines of 4800 collective I. H. P., driving twin screws. The designed speed was 17 knots.

On her official trial, the *Katahdin* proved to be a remarkably seaworthy and handy vessel, fully establishing the excellence of her design in these respects. While there was a moderate surface sea, neither the pitching nor rolling of the ram was appreciable. During the steering tests, the helm was put over from hard-a-starboard to hard-a-port in 17 seconds, the greatest angle of heel being but 1½ degrees, there being no vibration, and the vessel turning readily and quickly, although she was at full speed. On her return, the wind blew half a gale with a moderate sea; the vessel then rolled slightly and easily, the waves breaking completely over the hull. In cruising, since her trial, the ram has sustained this reputation for sea-keeping qualities. Her command-



FROM A COPYRIGHTED PHOTO BY A. LOEFFLER, N. Y.

THE RAM "KATAHDIN" OF THE UNITED STATES NAVY.

ing officer has stated, in effect, that she is as easy in the trough of the sea as otherwise; and that, in heavy weather, a tumbler of water, placed on the cabin table, would not be upset.

The trial speed, however, was not satisfactory, being but 16.11 knots, while the contract called for 17. The Secretary of the Navy, however, having stated that, despite this, he considered the *Katahdin* "a desirable vessel for the navy," and having recommended that he be given authority to accept her, Congress passed the act, approved January 4, 1896, by which the United States Navy acquired finally this novel fighting machine.

The failure to attain the desired speed gave added force to the criticisms which had been made as to the departures from the Ammen design, in the forward part of the ram especially—the changes in which are shown, in longitudinal and transverse sections, on page 228. It will be seen that the downward curve of the bow has been replaced by a structure above the "knuckle," whose midship line is horizontal for a considerable distance, and then turns down sharply to the stem. There will be noted, further, in the cross sections of this raised deck, the great weakness of the latter, both laterally and against projectiles, as compared with the corresponding section of the original design.

It has been said that these added tons of useless weight were loaded on the bow to keep the vessel from "diving"—a feat, which, for the Ammen design, was a physical impossibility, and which, even admitting its possibility, would surely be helped, not hindered, by the changes which gave to this imaginary "diving" bow a marked increase in weight. It is quite true that the bow of that design curved downward; but, against this, there must be put the tendency of vessels at speed to "squat" at the stern, thus raising the bows; the fact, that, in the original Ammen design, the under and angular part of the knuckle formed what were, in a measure, side-rudders, which would resist depression; and, more important by far than these, the further fact that the rapidly rising line of the elliptical keel from amidships to the stem, would tend rather to make her soar than "dive."

That these changes have affected the speed of the *Katahdin* most harmfully seems beyond doubt, since there is inevitably a most useless expenditure of energy in raising abruptly, along a sharp incline, ending but ten feet from the ram, a mass of water, only a part of which, with the gentle slope of the original design, would have reached the same height in about sixty feet of the vessel's length. It is not the weight of water carried on the bow which is of importance, but the energy expended steadily in raising it.

It seems apparent, that, in the useless work of lifting this mass in an abrupt and ever breaking wave, lies much of the lost energy which would have given the *Katahdin* her designed speed. In an official communication to the United States Navy Department, Admiral Ammen stated in substance, as to the change of form of the deck part of the bow above referred to, that, had the original lines been built instead of the raised bow, the resistance with the former would not have been more than one-fourth of that due to the latter.

Again, by the shoulder built on the upper forebody, instead of the curve, as designed, a dense spray is thrown up, to the great detriment of the helmsman's field of vision. An observer, on one of her preliminary trials, stated:—

"As the waves dashed over her it made a grand spectacle. The prow buried itself deep in the water, and as the vessel forged ahead the bow pushed great volumes of water ahead and to either side, and a perfect curtain of water rose in front to a height of ten feet. This would break now and then, throwing tons of water back on the deck nearly to the conning tower. The big capstan, as the water broke around it, throwing the white spray high into the air, had the appearance of a gigantic fountain."

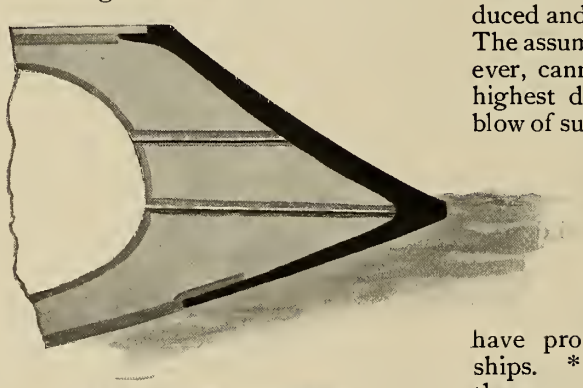
This "grand spectacle," this "perfect curtain," this "gigantic fountain," are strong, yet anything but cheering,

criticisms on the wisdom of the changes in the Ammen design.

It has been said further, as to the immersed bow section of the *Katahdin*, that neither its longitudinal nor transverse lines are curved, but are made up of chords of small arcs. If this be correct, the speed of the vessel would be impaired from this cause alone, without regard to the other considerations above set forth. An eminent British naval architect is said to have described the immersed bow of the ram as being "a good deal like the rind of a muskmelon" in its corrugations.

The offensive power of the *Katahdin* has been criticised, severely, but absurdly, the strictures being based apparently on an erroneous conception of the character of the blow which she delivers on, and not below, the armour belt. Comparisons have been made between her striking power and that of a projectile from a high-powered gun of large calibre.

Such arguments seem fallacious. The



THE BOW OF THE "KATAHDIN."

projectile, relatively to the ram, is a moving body of small weight and high velocity, whose effect is designedly local in punching or boring a hole in armour-plate, passing onward, if it penetrate, to damage the vitals of the ship. On the other hand, the ram, as compared with the projectile, is a moving body of great weight and low velocity, whose blow—with the same, or greater, energy than the projectile—is designedly a battering one. Since it cannot penetrate, its force must be expended in driving in, rupturing, and racking the armour and backing. As to criticism of this character, Admiral Ammen has said:—

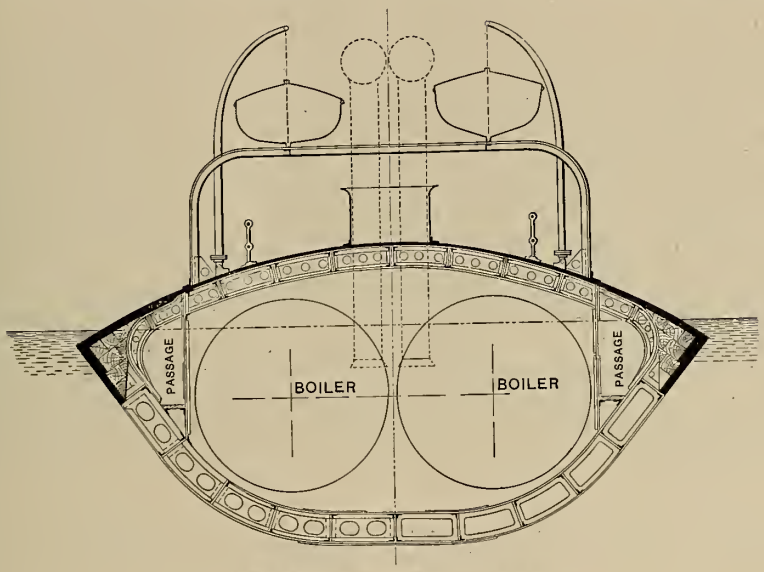
"No vessel of any weight and having even a high speed, would be able to pierce armour-plating; but the Ammen ram, as designed, would be abundantly able to disrupt the armour backing, which would be thrust in, the armour plate serving to increase the damage, rather than acting as a protection."

This opinion seems to be sustained, not only by past experience, but by high professional authority. In Tegetthoff's blow at Lissa and those of the *Iron Duke*, *König Wilhelm*, and *Camperdown*, the energy was less than that of the *Katahdin* at her maximum speed; and yet, Sir William H. White, in his report, as Director of Naval Construction of the British Navy, on the loss of the *Victoria*, says, in part:—

"It has been asserted that, if a strong armour belt had existed at the place where the blow was struck, the damage to the *Victoria* might have been greatly reduced and the ship kept afloat. * * * The assumption of impenetrability, however, cannot be admitted. It is in the highest degree probable that, under a blow of such energy as was delivered on the *Victoria*, the strongest armoured side ever constructed must have yielded and been driven in.

"* * * In other collisions, heavy blows, delivered nearly at right angles, have produced fatal results on belted ships. * * * In the *Vanguard*, the armour was driven bodily inward more than a foot and the bottom plating was torn open to the extent of about 25 square feet. This armour was only 6 to 8 inches thick, it is true; but, on the other hand, the force of the blow was only about two-thirds that delivered by the *Camperdown*. * * * In the *Grosser Kurfürst*, the armour-belt proved equally incapable of saving the ship. * * * Other cases are on record, but need not be cited, proving that the existence of an armour-belt is no sufficient safeguard against injuries resulting from serious collision."

The force of a ramming blow varies as the square of the speed in feet per second. The energy of the designed speed (17 knots) of the *Katahdin* is, therefore, to that of her attained speed (16 knots) as 823.69 is to 729, representing a loss of about 12 per cent. This loss, it would seem, the changes noted above should largely explain. While serious, it does not reduce her efficiency very materially and her performance, in other respects, seems to have vindicated—in a degree remarkable with so experimental a structure—the excellence and accuracy of her design.



A CROSS SECTION OF THE "KATAHDIN."

The practical invulnerability of this vessel, her power to strike a crushing blow, her facility in turning, and her seaworthiness in weather during which ironclads would be storm-bound in port, should make her feared more than a battleship by a hostile fleet cruising off the coast So far as built upon the original design, she has shown admirable qualities, and the alterations made demonstrated fully the damage resulting from them. In view of her remarkable offensive strength and her low cost relatively to that of a battleship, the attempt to protect the vast coast-line of the United States by the latter mainly would seem to be an expensive mistake. The development, then, of the Ammen ram, in displacements of not less than 5000 tons, on the original, and not the changed and erroneous, lines, would seem to be a wise measure of naval defence for the United States. As will be shown further on, Admiral Colomb, R. N., sustains, in a measure, this view as to the battleship and the ram, including with the latter, however, the torpedo.

The Ram's Characteristics: Its Strategy and Tactics.

At this time, there are few sciences which are more speculative than that of naval tactics. This is necessarily so from the modern revolution in much of the material of naval war and from the scanty experience with that material in actual conflict. Some years ago, Vice-Admiral Colomb, R. N., compared aptly the naval tactician to a man in a bog, putting out a foot here and feeling a tussock there, which he would test carefully before attempting to rest on it. It is to be expected that, on so vexed a question as that of the ram, there should be opinions varying widely.

There can be no doubt as to the over-

whelming destruction of a ramming blow when fairly delivered. The striking force in foot-tons of a ship in motion equals $\frac{Wv^2}{2g}$, in which W denotes her tons displacement; v her velocity in feet per second, and g is, approximately, 32. This formula, for even vessels of moderate tonnage at moderate speeds, gives a kinetic energy measured by tens of thousands of foot-tons. Professor Laughton, R. N., is well within the mark, when he says:—

"All analogy leads me to believe that a direct blow, delivered by a ship such as the *Hercules*, of 8000 tons displacement, at a speed of 12 knots—that is, with a kinetic energy of 50,000 foot-tons—would require no repetition. * * * It is a question which only deadly combat could decide, whether the striking ship would not pass through, and over, the shattered wreck."

Admiral McCann, U. S. N., in the report of the Naval Policy Board of 1890, stated the matter broadly thus:—

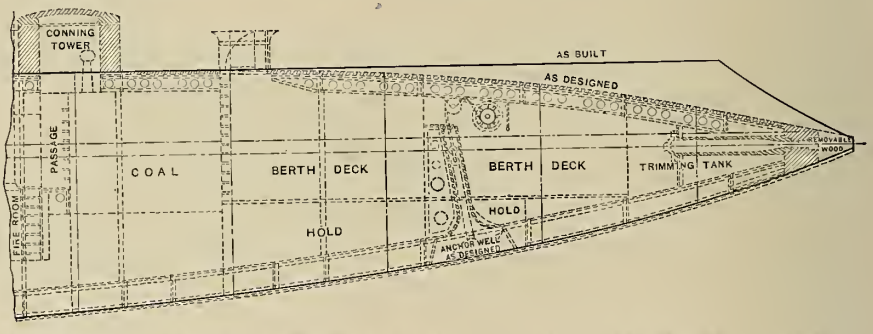
"No blow which can be inflicted by any weapon other than a mine or torpedo, carrying very large quantities of high explosives, can compare in effect with that of a vessel itself, moving at a high rate of speed."

It will be noted that the kinetic energy varies as the weight and as the square of the speed. The latter is, then, the more important element. Indeed, great weight is not an advantage, since it implies large displacement and slow manœuvring. Since fair speed with moderate tonnage gives much energy, Admiral Ammen, U. S. N., says:—

"Great speed is, doubtless, a requisite for an effective ram—not, in my belief, either to overtake or to sink an enemy, but to get rapidly in and out of action."

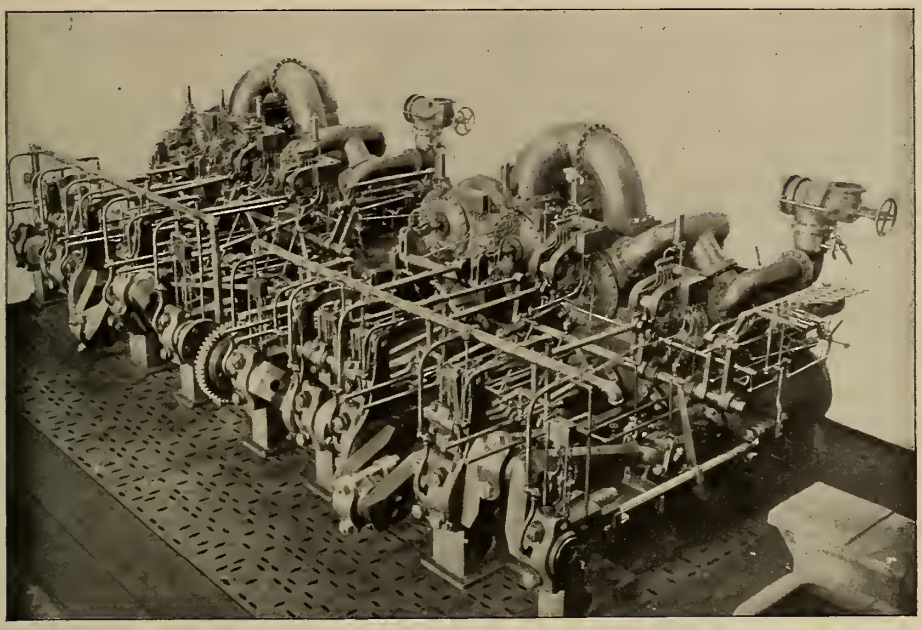
The most effective position of the ramming spur seems still an open question. In recent British practice, it is sunk to a considerable depth; in the latest United States battleships, it is somewhat higher,—about 9 feet below the water-line; while the French seem now to favour placing it at, or near, that line. Admiral Sir George Elliott, K. C. B., has said, as to the spur:—

"The object of this protuberance is plainly seen to be that of entering a ship below the armour-belt; but, in many cases, it may counteract its own intention, as it is obstructive to handiness. * * * The less there is of cutwater and keel, the better for handiness. * * * If a ramming blow is struck at all fair, it will most probably crush in the side at the water-line."



SKETCH SHOWING SHAPE OF BOW OF THE U. S RAM "KATAHDIN" AS DESIGNED AND AS BUILT.

A high ram, as in the *Katahdin*, permits a curved and rising keel, and, therefore, great manœuvring power; and its blow, although delivered on the armour-belt, would seem, as previously noted, to be effective. While a low ram strikes the thin hull-plating below the armour belt, it acts to depress the bow when at speed; it forbids the greatly curved keel with its attending handiness; and, since it must pass through to the inner skin to be effective,—a distance of 38 inches in the



THE ENGINES OF THE U. S. RAM "KATAHDIN," BUILT BY THE BATH IRON WORKS, BATH, ME.

United States battleship *Alabama*,—the chances of the rammer becoming entangled in the wreckage are greater than with the higher position. Furthermore, unless the low spur project considerably, its rising, reverse curve will strike the lower edge of the belt—as with the *Iron Duke*—before its apex pierces the inner skin, thus limiting its offensive power to that of the high ram.

Not only skill and nerve, but instant decision, will be needed for the effective use of the ram with the swift ships of this day. Some one has compared an attempt to ram a 20-knot cruiser, at full speed, to the effort to "lasso a thunderbolt." However, neither cruisers nor battleships will move at this speed in action, as they would vanish from the field. Captain Long, R. N., said, in 1884:—

"A ship, 300 feet long, going at 12 knots, will pass over her own length in 15 seconds, and the other ship, the same; the consequence will be that the time during which these two ships will be in a position (when they have to turn) to ram each other, will be 7½ seconds; minutes do not enter in."

Captain Mahan compares skill with the ram to the art of the swordsman. Captain Hoff, U. S. N., writes:—

"Lord Nelson said that there were only five minutes difference between victory and defeat. Captain Rivet, M. F., says, with fast ships such as are used nowadays, for 'five minutes,' read 'five seconds.' Captain Colomb, R. N., says, very truly, that the difference between ramming and being rammed lies in 'half a ship's length.'"

Mr. H. W. Wilson, in "Ironclads in Action," draws a still darker picture:—

"The utmost skill will be necessary to deal a blow with the ram. At very close quarters, a furious hail of projectiles will crash upon the conning tower, and render the direction of the ship a matter of extreme difficulty. And there is great risk of being rammed by the enemy, if there is any miscalculation, or, without miscalculation, of being torpedoed."

The shock from a ramming blow is, of course, very great on the stricken ship, while, on the rammer, it would seem to be but slight. Although the

bow of the *Victoria* was thrown violently 60 feet to port, the feeling on the *Camperdown* was "as if they were cutting into a soft sand bank." The *Iron Duke* suffered no injury. On the *König Wilhelm* there was but "a gentle trembling." With the *Ferdinand Maximilian*, at Lissa, the shock was not great, although some men were thrown to the deck.

The damage to the bows of the ramming vessel is a varying quantity, dependent on her speed, that of her opponent, the structure and contour of the bow, the angle of the blow, and the character of the entanglement. The *Iron Duke* charged without injury; the ram of the *König Wilhelm* was fractured and bent; the *Ferdinand Maximilian* but scraped her paint; and the *Huascar* had her bow-plates and backing broken.

In a lecture before the United States Naval War College, Passed Assistant Engineer W. M. McFarland, U. S. N., showed the immunity of the propelling machinery of the charging vessel. He said, in part:—

"There seems to be the idea prevalent that, when one vessel rams another, the attacking vessel is almost sure to damage her own machinery. * * * It (ramming) is not the case of the irresistible force striking the immovable obstacle. * * * The effect is somewhat analogous to that of brakes on a railroad train, in bringing the speed from a high figure to a low one in a comparatively short time."

Mr. McFarland then cites cases as follows:—The *Sassacus*, at 11 knots, rams the *Albemarle*, "without dislodging the machinery or injuring it in any way." The *Wachusett*, at 4 to 5 knots, rams the *Florida*, with "no damage to machinery." The *Arizona*, at 14 knots, strikes an iceberg, and "the machinery was as perfect as before" the blow. The *Camperdown*, at 6 knots, rams the *Victoria*, and "the engines worked afterward as if nothing had happened." A Yarrow torpedo-boat, at 18 knots, struck a heavily laden barge, but "engines, boilers, and machinery were not at all injured.

In an essay, entitled "The Ram in Action and in Accident," read before the Royal United Service Institution, Mr. William Laird Clowes examined 74 cases of ramming, or attempts at it, in naval warfare, from the outbreak of the American Civil War to October 8, 1879; and presented, exhaustively, in tabular form, the conditions and results of the attacks. The conclusions of Mr. Clowes, based on his tabular results, were:—

"One is, that, if two ships have sea-room and be fully under control, it is actually more dangerous to try to employ, than to try to escape, the ram; and, that, under these conditions, it is practically hopeless to dream of ramming effectively, since there is no recorded case of the operation having been performed, although it has been attempted at least thirty-two times.

"Another is, that, in such circumstances, the rammer stands about the same chance as the rammed does, of sustaining non-fatal injuries. Another is, that, the risks attendant upon ramming are the same, whether the attempt be made at sea or in narrow waters."

In view of the nature of these conclusions, it is important to note the characteristics of some of the ramming vessels upon whose performance they are based. Forty-five of the cases cited—about 60 per cent.—occurred during the American Civil War; their results, therefore, dominate in the summation. In observing the qualities for offence and resistance to injury of the assailants in these forty-five attacks, we find, as to the Confederate ironclads, that the *Merrimac* could make, at best, but 5 knots, and her spur was ill-attached; that the *Tennessee's* best speed was 6 knots and was lower still when she tried ramming; that the *Arkansas*, with funnel shot away, could do but one knot per hour; and that the *Albemarle's* engine-power was so feeble that she would not steer when going with the current and so "came down the river backward, dragging chains from the bows." Indeed, all of these vessels steered badly. The famous *Manassas* was but a converted tug-boat, with a speed of 5 knots.

The *Governor Moore*, *Stonewall Jack-*

son, *Bragg*, *Price*, *Van Dorn*, and *Beauregard* were river boats, mainly side-wheelers of but moderate speed, with scanty equipment for ramming. The *Governor Moore* struck fatally the Federal *Varuna*, 1300 tons, 10 guns, and yet Beverley Kennon, her captain, said of the *Moore*:—"Her stem was like that of hundreds of other vessels, being faced its length, on its edges above water, with two strips of old-fashioned flat railroad iron. * * * The other eight 'rams' (below New Orleans) had their 'noses' hardened in like manner." The Federal *Monarch* and *Queen of the West* were also river-boats, but were somewhat stronger, as to the bows.

According to Mr. Clowes, the Federal *Essex* was very slow, and the *Monitor* a little faster than 5 knots. The *Sassacus* was a wooden, side-wheel, double-ender, with a bow rudder. The *Harriet Lane* was a revenue-cutter. The *Commodore Perry* and *Keystone State* were purchased merchant vessels. The *Wachusett*, *Monongahela*, *Ossipee*, *Lackawanna*, and *Hartford* were wooden sloops-of-war of the transition stage between sails and steam, fully rigged, with fairly bluff bows, but moderate speed, and having a bridge forward for the commander and the steering wheel aft, under the break of the poop—an arrangement which precluded the instant handling of the helm which ramming requires. As to the remaining vessels, the *Neptune* and *Niphon* were probably purchased merchantmen and the *Webb* and *Bayou City* were river steamers. In them all there was probably not one collision bulkhead nor water-tight compartment; and, in by far the larger number, the equipment for ramming was absent or of the crudest type.

In considering their performance, the wonder seems to be, not that they struck so seldom and suffered so much harm, but that, in view of their unfitness, they scored, relatively, so often and with so little injury to themselves. In any event, it would seem, that, for the conditions of this time, deductions from their performance can be made only in the most general way. In earlier days, when Lissa was fresher in men's minds, Captain Noel, R. N., wrote:—

"The general opinion of the value of rams may be gathered from the following extracts, all from the United Service Institution journals. Captain Colomb, in his paper on 'Lessons from Lissa,' says:—'Let us just recall the fact that the serious part of a future naval attack does not appear to be the guns, but the rams.' Again, he quotes from a French writer, Admiral Touchard:—'The beak is the principal weapon in naval combats, the *ultima ratio* of modern war.' Captain Pellew, in his lecture on 'Fleet Manœuvring,' says:—'Rams are the arm of naval warfare to which I attach the chief importance. In my opinion, the aim of all manœuvring and preliminary practice with the guns should be to get a fair opportunity for ramming.' Captain Dawson admits the great importance of rams, and, in his paper on 'Naval Guns,' says:—'Under many conditions of battle, as ships are, at present, equipped, the stem, whether employed to run into high-sided, or to run over low-freeboard, vessels, would occupy the foremost position.' All of these opinions are to the same effect. * * * I would go further and say that all ships ought to be rams, and all officers ought to be practised in manœuvring them."

In 1884, Captain Noel, while still believing the ram to be the arm of first importance in a general action, stated that "in single-ship actions, the gun will take the priority." Admiral Colomb, also, at this time, gave his views, generally, thus:—

"I think that a heavy gun-ship will not expose herself either to the ram or the torpedo, if she can help it. I think she will endeavour to prolong the gun-action and the torpedo-action as long as possible before the ram can be brought into play. And then it appears to me that the general policy we have to follow would be to make the ram efficient certainly, but not to sacrifice too much to it. * * * And to understand that you cannot force your ram action."

Admiral R. W. Meade, U. S. N., has said:—" Every vessel in the navy may, and ought to, have a strong bow, capable of being used as a ram, if pressed hard and occasion serves."

Lieutenant Commander Wainwright, U. S. N., says that the commander of a well-equipped fleet should " first use the gun until he has disabled a portion of the enemy's fleet: then the great value of the ram would be seen. * * * Its value (at that time) far exceeds that of the gun."

Admiral Fremantle, R. N., expresses, in a measure, similar views, stating that, although the ram is a most important weapon, he puts it " a little in the background, at least at the commencement of hostilities between fleets."

Admiral Sir George Elliott, R. N., believed, that, unless hostile fleets shall approach each other in very open order, " fleet actions will, from the first, become a *mêlée* and that bow to bow ramming will be the ruling feature of the fight."

Whether a ship, built especially for ramming, should be without a battery, has been much discussed. Captain Eardley Wilmot, R. N., sums up the objections to this, thus:—

" When guns were the only weapons to contend with, there was some reason to construct a vessel impervious to projectiles and relying solely on the ram. The torpedo alters this condition; as, before the ram can be applied, such a vessel must come within the torpedo's range. * * * Then I fail to see the advantage of denying a vessel guns on the plea that their smoke would be an encumbrance when ramming. A captain has the power of withholding his fire at all times. * * * Lastly, a vessel without guns, disabled in her machinery, is at the mercy of any antagonist."

On the other hand, Admiral Gore-Jones, R. N., believed that the ram " ought to be a weapon, like cavalry in the army, used for its own purpose and for nothing else;" that " the ship ought to have no fighting power in it, except to ram." And, Admiral Ammen, U. S. N., while giving similar views, calls attention to the irresolute Persano at Lissa, who, on a ship with both rams and guns, neither rammed nor used his battery effectively. " If," the Admiral continues, " a ram has no heavy guns, there is obviously but one thing for the commander to do; and that fact cannot be forgotten. " Captain Sampson, U. S. N., in referring to the ram, pure and simple, says:—" Indeed, the vessel herself is the projectile, and to complicate its use with that of guns would serve only to detract from its efficiency."

A remark made by Farragut, as to an officer's environment in battle, would seem to have a bearing on the question of giving a weak man the option of ramming, or firing. In discussing battleship construction with Sir E. J. Reed, he was emphatic in advising the latter " to keep things as simple as possible and warning me (Reed) not to depend upon either officers or men handling complicated things under such circumstances," that is, in action.

For coast-defence, the ram, without armament, has been discussed favourably, especially in the United States, with its long stretches of unguarded shore. Admiral Ammen, who does not favour such vessels for fleet-service, has said of them, as coast patrols:—

" A fleet of rams, in readiness to attack an armoured fleet, would not have long to wait. A moderately rough sea, a fresh breeze, with a bright moon or the early dawn, would offer advantages of attack that would not exist, were it to be made by battleships. A good light is necessary to sight guns, and very little to run into a vessel. The huge hulls would be plainly in sight from the rams a mile away, and the latter would be invisible until quite near. The rams would have their steam at its best and the armoured ships would have theirs as it might happen."

As to the cost of construction and maintenance of such a fleet, the admiral adds:—

" Five rams can be built at the cost of two of our battleships * * * and the expense for maintenance of the five will be less than for one battleship."

In 1864, Admiral Sartorius, R. N.,

said, as to a night attack by rams:— "The ram can approach to a couple of hundred yards without being seen, and the rapid approach and change of angles make it extremely improbable that any guns can be fired with precision enough to hit her, before the prow of the ram is driven into the side of the vessel pursued."

Since these views were expressed, search-lights, machine and rapid fire guns, and torpedoes have come into general use; and yet we find Captain Sampson, late Chief of Ordnance U. S. N., writing in 1889:—

"The office of the ram in coast defence will be similar to the torpedo boat, acting on the offensive by making excursions against the enemy at night and in thick weather; in attacking a vessel that has been disabled by gunfire or torpedo, or that has grounded, or become deprived of the support of her companions from any cause, as well as acting in conjunction with other vessels in a general attack."

In view of the expressions quoted above as to patrol-fleets and night attack, it is interesting to note, that, in a recent essay, "The Future of the Torpedo," Admiral Colomb, R. N., says:—

"Fifteen destroyers, acting together, could drive one battleship off the sea. How could we speak of battleships commanding the sea, when they must at night seek the shelter of close harbour?"

If, then, the destroyers shall fight in sufficient numbers, the admiral's view is that they will be masters of the battleships, despite the value of the latter against other foes. It is of interest, farther, to observe that in planning his ideal destroyer, the admiral describes the torpedo-ram—an armoured vessel, with curved deck, fighting awash, and attacking, in fleets, with the torpedo and the ram.

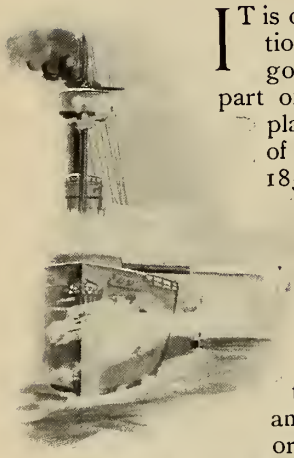
The torpedo develops slowly and is still an uncertain weapon. The automobile type has yet to win success in battle against ships in motion. It is, in some types, subject to deflection, if discharged from broadside tubes when a vessel is at speed. In under-water broadside tubes, it is liable, further, to injury during discharge. Above-water tubes would seem to be a source of danger in action, especially if unarmoured. Bow-tubes, in battleships, have been criticised with regard to the danger of the vessel overrunning her own projectile.

It seems, at best, a weapon of errant aim and limited range, although of great destructiveness, if it should reach the mark. The claim, then, met so often, that it gives full protection against the ram, that it has "relegated the ram into obscurity," seems somewhat broad, when in addition to its admitted defects, it is noted that, with one prominent type, if the torpedo travel straight, its track can be observed and that it is a possibility for a vigilant, swift, and handy ship, by quick manœuvring, to escape it.

The story of the ram is not yet "a tale that is told." The great naval powers may keep, for years, an armed peace, and, for years, the naval tactician may flounder in his bog of uncertainty as to the relative value of his weapons. The war-dogs, however, are but chained; and some day, in some final conflict, some Armageddon of the sea, the gun, the ram, and the torpedo will fight it out. It would seem that, in such ultimate strain and stress alone, can there be determined the primacy among them.

A CHAPTER IN THE HISTORY OF WAR SHIP-BUILDING IN GREAT BRITAIN AND FRANCE.

By Sir Nathaniel Barnaby, K. C. B.



IT is open to serious question whether it was good policy on the part of France to armour-plate the sides of ships of war as she did in 1854-'55 There can be little doubt that the initiative in this novel proceeding was due to the Emperor Napoleon III. It was the conception of an artillerist, and not of a seaman or a shipbuilder.

It has always seemed to me that the arguments by which he supported the policy were unsound. The end he sought was the power of attacking land fortifications from the sea, without risking disproportionate loss in the ships making the attack. He set off the value of the units of the floating force of line-of-battle ships in contrast with the much less costly land fortifications. He met the difficulty, not by reducing the cost and increasing the number of the units of the sea force, as he might have done, but by armour plating still more costly and less numerous units.

He might have employed inexpensive gun vessels, mounting one heavy gun in each, and then he might have regarded with comparative indifference the loss of some of his vessels under the enemy's fire. He preferred to attack the Russian forts at Kinburn in vessels mounting many guns, covered above the water with armour, and costing much money in *matériel* and *personnel.*

He did not foresee the torpedo attack from fast boats, or the rapid decay of the wood frames and planking under the armour. He lived long enough to change his views, and during his exile he proposed a first-class ship in which all the guns were mounted on a deck, in the open, with no armoured cover for them. But the fashion which he had set in 1854 was too firmly settled to be abandoned lightly. France is fertile in devices and surprises, but the very latest Parisian mode for ships is a complete coat of thin steel.

Whether Great Britain acted wisely in following the French lead in 1854 is also doubtful. But it was followed. Happily the English counsels were influenced by men who were fully alive to the disadvantages connected with the use of timber in building such ships. Great Britain had, at that time, huge stores of English, Italian and Dantzic oaks, and much also of the inferior American white oak. These were so stacked in her dockyards as to admit of storage for years, not only without decay, but with increase in strength and durability. Yet it was decided to build the first armoured frigate in her navy of iron.

The shipwrights in the Royal Dockyards were the most skilled of their craft in the world; nevertheless, it was thought right to enter boilermakers and get them to build ships at Chatham Yard, while the shipwrights were either learning to handle unfamiliar tools, or were employed on other work. The first of these British ships was commenced on the Thames in 1859.

But building in wood for the reception of armour plating was not to be abandoned. Conservative instincts were too strong for that, and in the years

1859 and 1860 Great Britain commenced to build seven ships of timber which were to be armour plated. These were of from 6000 to 7000 tons displacement. They were the *Repulse*, *Royal Alfred*, *Zealous*, *Caledonia*, *Ocean*, *Prince Consort*, and *Royal Oak*. In 1863 the *Lord Clyde* and *Lord Warden*,—two still larger ships,—were commenced. In these ships the timber frames and planking decayed after comparatively short service, and the names of the ships disappeared from the Navy List.

The feeling in Great Britain that the new armour-plated navy must be built of iron strengthened, and it was decided to sell by forced sales, but gradually, the vast store of timber which had been the pride and boast of many successive Admiralties. French administrators were less clear-sighted and continued to build of timber.

For some years longer British ships were built with wood planking and iron frames when it was not proposed to armour-plate them. But this course had eventually to be abandoned. Increasing engine power and greater lengths in the ships demanded the support of an iron skin as well as iron ribs, and eventually timber disappeared from both the ribs and the skin of the unarmoured ships. Where wood planking is still used in the main structure of a ship it is only as a bed to receive copper sheathing.

In all the ships to which reference is here made, the propelling machinery was kept below the water level unless it was covered by side armour. Where there was no armour the risk of damage to the machinery and magazines from plunging fire or bursting shells led to the introduction of covering decks of iron or steel in order to protect these vital parts. Such ships were called "protected" ships to distinguish them from armoured ships and from ships in which the vital parts had no such protection.

In all these respects France moved slowly. She is quick at initiative, but slow in following the lead of others. She continued to build with wooden frames in both armoured and unarmoured ships, and to build unarmoured iron ships without protecting decks.

It was clearly seen in Great Britain, and by naval constructors in France, that this was faulty policy, and that France was forming her navy upon insecure foundations. For a good many years past her administrators have admitted this, and they have now definitely abandoned wood ship-building, and unprotected iron ship-building in warships, and have been rapidly removing such ships from the sea going fleet.

It will be interesting to note the effect of this as shown by a comparison between the lists of large sea-going ships in the two navies in August, 1885, and August, 1896, which are the dates of two British Parliamentary returns. Looked at on paper, without regard to the peculiarities which have been pointed out, the French Navy, in and before 1885, appeared to be so formidable that serious charges were made by writers on naval questions in Great Britain at this and previous dates against British naval administrators. They were charged with indifference to the comparative weakness of the British Navy. It was urged that it hardly exceeded that of France, without regarding possible combinations against it.

It is not necessary to refer to the conflict of opinion in Great Britain as to the wisdom of adhering to muzzle-loading guns, which had weakened the heads of every administration for years. Happily we are able to appeal to the judgment of the French naval administrators between 1885 and 1896 on the point. During that period they removed from the sea-going list as many as they could of the ships which were either wood-framed or were without protection for machinery and magazines. The Parliamentary return (Sir Charles Dilke's) of 1896 shows this.

Of sea-going ships of 2000 tons displacement and upwards, France had, in August, 1885, completed for sea, sixty ships. Of these, thirty-nine were armoured. The rest were unprotected. Of corresponding ships Great Britain had seventy five, of which forty-two were armoured and sixteen protected.

In August, 1896, of these sixty French ships, thirty-one had been removed from the sea-going list. Of the seventy-five British ships only twenty-one had been removed. Of the fifty-four British ships remaining on the list of 1896 and which had been on the list of 1885, not one was built of wood. Of the twenty-nine French ships corresponding, *i. e.*, ships appearing in both lists and still retained for sea-going service in 1879, twenty-one are built of wood.

Following the French judgment so far as these twenty-nine ships are concerned, and removing from the list all the unprotected ships and ships built of wood, we have only five ships left. Dealing with the British list in the same manner there are forty-six ships left.

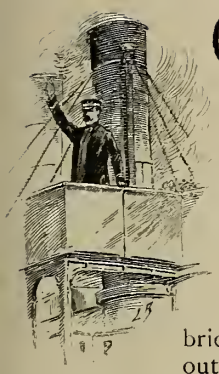
The only French ships of the kind we are considering, *i. e.*, sea-going ships of 2000 tons and upwards, which appear as completed ships both in 1885 and in 1896, and which are neither wood built nor unprotected, are the following:—*Friedland*, *Redoubtable*, *Devastation*, *Duperre*, and *Vauban*.

In August, 1885, the French were making great efforts to remove these elements of weakness, and they were building fourteen ships, of the power we are considering, half of them heavily armour-plated, and none of them without protection. These ships were to carry 177 guns of not less than one ton weight each. At the same date we were building twenty such ships, some armoured and all protected, which were to mount 223 such guns.

There are those who still believe that the British Navy of 1885 was weak as compared with that of France. The belief is, as has been shown, ill-founded.

TORPEDO ATTACKS.

By Lieutenant R. C. Smith, U. S. N.



ONE of the most valuable contributions made in recent years to the literature of torpedo-boats and their several outgrowths is a prize essay, entitled "Torpedo-Boat Policy," which Lieutenant Smith submitted last year to the United States Naval Institute. From this the following brief extract has been made, outlining the conditions under which, in general, torpedo-boat attacks are likely to be executed.—THE EDITOR.

With the modern batteries of rapid-fire and automatic or semi-automatic torpedo-guns, it will be impossible for the torpedo-boat to exist for more than a very limited time if she is discovered before reaching torpedo range. What that time is may well be open to discussion. It will depend on the atmospheric conditions, the amount of light on the boat, the speed of the boat, the state of the sea, the number and character of the guns that can be brought to bear, and the expertness of the gunners. The boat then must try and get as near as possible before she is discovered at all, and the ship must find a way to discover and destroy the boat before the torpedoes can be launched.

With the present development of the automobile torpedo as a weapon of war, 500 yards is the admitted effective range. Now as to the best means at the disposal of the offence to bring its weapon to this range of 500 yards and of the defence to prevent it, the smaller and more invisible the boat, the darker the night, the greater the absence of noise, as from the blowers, of flame from the funnels, or of disturbed water at the bow and stern, the less will be the chance of discovery, either by the ship or by her destroyers or vedettes, with or without the assistance of search-lights. Speed would be of advantage in taking the boat more quickly through a zone in which there might be danger of discovery, but if at the expense of noise, or flame, or water disturbance, the gain would be questionable.

The ship attacked may be either at anchor or under way. If at anchor, the means of defence consist of obstructions, such as chains and booms, torpedo-boat destroyers cruising about the harbour entrance, vedette-boats and pickets distributed on inner lines, and fixed beams of light illuminating zones across which attacking boats must pass. The search-light used in any other manner is condemned by all the best authorities. It affords a mark for the attack, and it gradually blinds the eyes of the watchers. When the boats are

A WHITEHEAD TORPEDO.

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DISCHARGING A TORPEDO.

discovered, the lights should be turned on them for the benefit of the gunners; and this and the other are apparently the only logical uses of the search-light. The fixed beams, above referred to, can be thrown from stations ashore or from special vessels other than those expecting the attack. The use of booms and obstructions will depend much on the locality and the time at the disposal of the defenders. Destroyers, vedettes and pickets, could, or should, be available under almost all circumstances. Defence-nets are not here mentioned, as they are considered undesirable.

If the ships are cruising, the best defence is to screen all lights, assume a formation compact enough to permit each ship to be visible from her neighbour, and to dispose the scouts, cruisers, destroyers, and torpedo-boats, should any of the latter be present, in such wise as to make it improbable that the enemy's boats shall break through to the larger ships.

In support of the arguments as to the use of the search-light, data from the United States Torpedo Station records will be of interest. In twenty-six different exercises that have taken place between the torpedo-boats stationed there and search-lights ashore, or in ships of the navy afloat, the average distance of discovery by the aid of the light was 781 yards; the greatest distance 2000 yards; and the least, practically zero, the boat having got alongside the ship without discovery. The weather during these exercises was generally good, never with any appreciable fog or mist, and occasionally with a full moon.

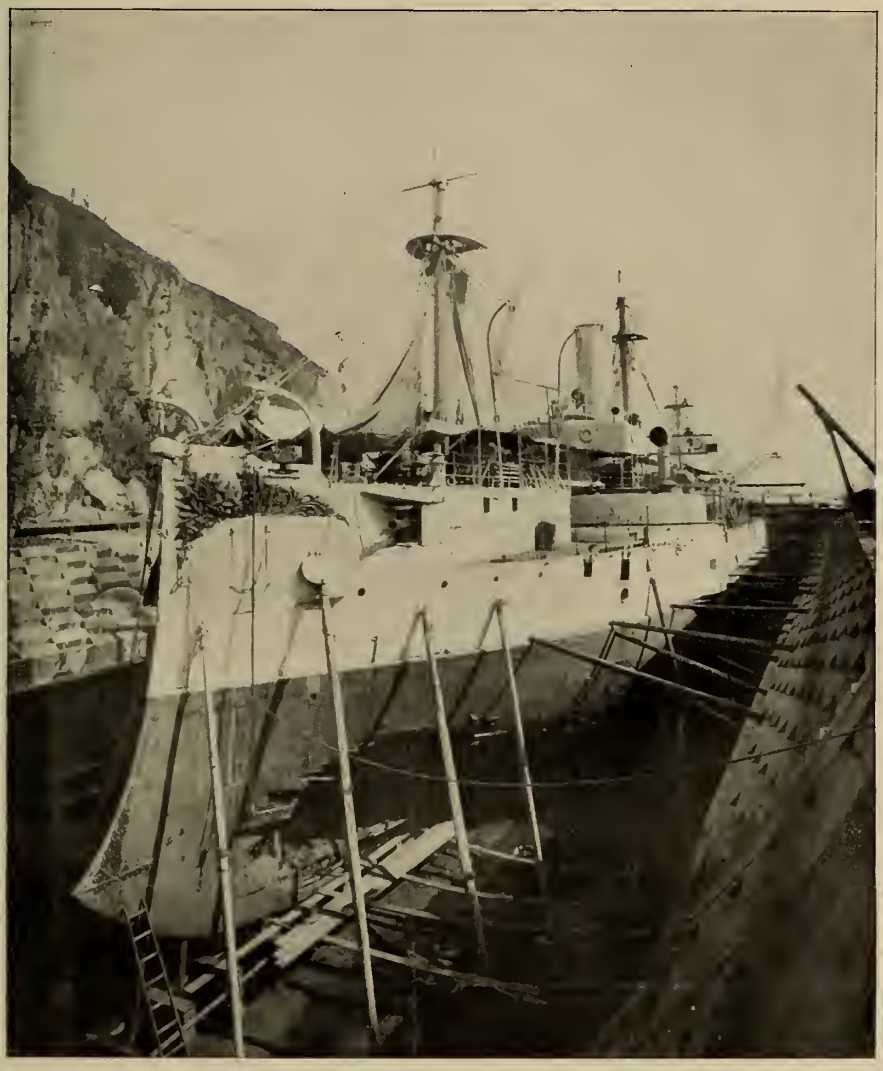
Other sets of figures were obtained by causing the boats to run out under the search-light to the limit of visibility. The distances under these circumstances varied from 1000 to 2750 yards. The difference is due to the great difficulty of picking up a small neutral-tinted object by a sweeping beam.

Now taking the average distance of discovery, as above stated, at 781 yards, in order to reach torpedo range of 500 yards, the boat must cross a zone of 281 yards, which at the moderate torpedo-boat speed of 20 knots would require 25 seconds. Is this sufficient to put the boat out of action? If not, the

chances of a single boat against a single ship depending only on search-lights would be more than one half. With several boats, making a preconcerted attack, the chances of the ship would be correspondingly less.

It may be stated that in all the exercises referred to no advantage was taken of cover, such as might have been afforded by vessels at anchor or outlying islands. In making an attack, the boats always kept in visible range of the search-lights within a radius of 2000 yards.

It is to be regretted that there are no definite data on which to base a conclusion as to the time that would be required to disable or destroy an attacking torpedo-boat. European practice in the annual manœuvres has limited the time from three minutes to one minute, the tendency having been gradually to



THE BRAZILIAN BATTLESHIP "AQUIDABAN" IN THE DRY DOCK, SHOWING THE RESULT OF A TORPEDO EXPLOSION.

reduce it. The United States Torpedo Station rules have required an interval of two minutes outside of 400 yards, equivalent to one minute and 48 seconds outside of 500 yards at the speed ordinarily used.

In Europe, the attacking boat has been required actually to make a hit with a dummy-head in order to score a success; but with regard to the time necessary to ensure the destruction of the boat, everything was surmise, an arbitrary rule governing. I understand that Captain Evans, of the United States Navy, has suggested an experiment at towing a light target, representing the cross-section of a torpedo-boat, at the end of a steel wire 1500 yards long directly towards the ship expecting an attack. The towing vessel could be a fast torpedo-boat. She would steam directly towards the ship at her highest speed under the conditions, the ship to turn her search-lights on the target and open fire the instant the torpedo-boat passed clear on the off side. The fire would be continued until the target was estimated to be at torpedo range, after which the hits would be counted. The line could then be shortened to reduce the interval of time under fire, and the experiment be repeated. Eventually there would be some very satisfactory data connecting speed, distance, time, number and character of guns, and number of hits.

From what I have seen of somewhat similar experiments in former years, except that the target was at rest, I am under the impression that in 25 seconds, the average time of reaching torpedo range from the probable distance of discovery, as determined by the United States Torpedo Station experiments, the torpedo-boat would not be found to be *hors de combat.* If the working range of the torpedo is materially increased by any new automatic steering device, all the arguments as above acquire added weight in proportion.

The rational defense of the ship, then, whether at anchor or under way, seems to be the scout, the torpedo boat destroyer, the torpedo-boat, the vedette-launch, and the picket-boat. Here, perhaps, is the field for the submarine boat.

POWER TRANSMISSION ON AMERICAN WARSHIPS.

By George W. Dickie.

THE matter presented in the following pages is the substance of a paper read at one of the recent meetings of the American Society of Mechanical Engineers, and, in its condensed shape, is the best exposition that has yet been made of the several systems of power transmission used on ships of war. Mr. Dickie, the author, is the general manager of one of the largest ship-building establishments in the world, and is thus admirably qualified to handle the subject. What he says is not designed to show the superiority of any one system over another, but simply that there is no mechanical difficulty in operating all naval auxiliary engines by any one of the systems mentioned.—THE EDITOR.

On vessels of the United States government the work which has to be done by machinery is divided up and placed under the cognisance of various bureaus, each having a decided preference for some particular mode of transmitting power, which might really be the best for the particular work of that bureau, but not applicable at all to the class of work under the cognisance of another bureau. The result is that in one ship we are very likely to find three different methods of transmitting power in use, and no one in charge master of any one method.

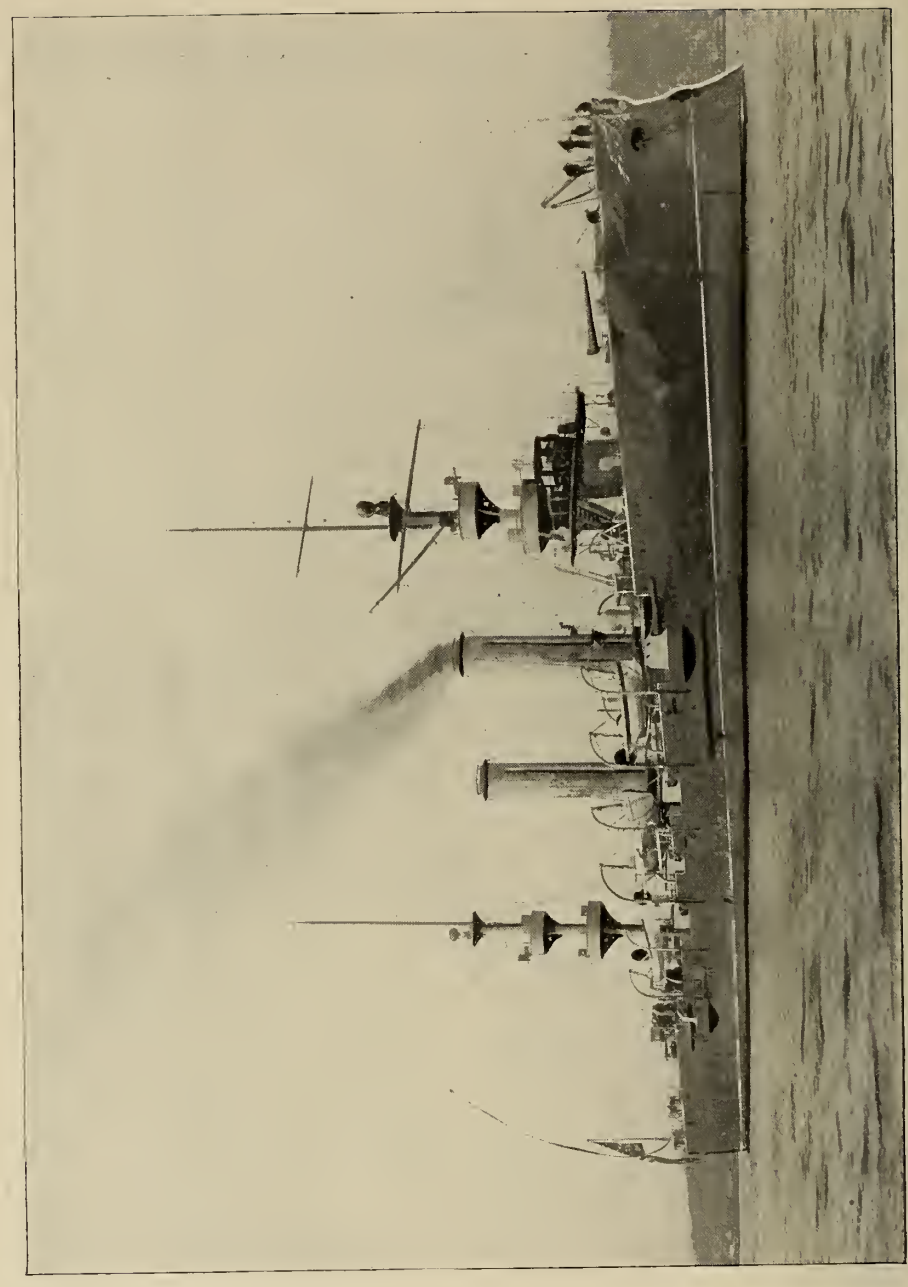
In mentioning three methods of transmitting power in use we exclude steam, that being the original form in which the power at present is generated, and therefore can be distributed without any reconverting mechanism.

Electric power is generated for lighting purposes, for controlling searchlights, operating small fans for special purposes, and for signal purposes. In quite a large number of vessels electric power is used to operate ammunition hoists, and in one or two recent cases the lighter turrets have been operated by electric motors. In some vessels now building a further extension of electric transmission of power is being made to include the large turrets and all the gun-mount movements of the large guns.

In some of the ships the distribution of power is divided between electric and hydraulic transmission, the main battery being operated, including the turrets, by hydraulic power, while the ammunition for all secondary guns is served by electric hoists. In others, the battle-ship *Oregon* being a good example, the main turrets and their guns are not only entirely operated by hydraulic motors, but all ammunition hoists throughout the ship, battle doors, etc., are worked from the same source of power. This vessel is also fitted with hydraulic steering gear.

Compressed air has been used to some extent as a means of transmitting power on some United States vessels, and is provided on all vessels carrying torpedoes for charging these intricate self-propelling projectiles. Colonel Soliani, chief engineer of the Italian Navy Department, has strongly advocated compressed air as a means of transmitting power for all purposes on warships, except for operating large turrets, for which he prefers hydraulic power.

There are also those who advocate



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THE UNITED STATES CRUISER "NEW ORLEANS," FORMERLY THE "AMAZONAS," OF THE BRAZILIAN NAVY.

the use of steam direct on all auxiliaries, including the working of all turrets, ammunition hoists, and even the manipulation of the guns.

In the present state of the art of transmitting power to all parts of a modern warship it is not possible to compare one method with another as a whole, and from actual experience, there being no one ship with a complete system of transmission from a central generating station of one type to compare with another ship having an equally complete system from a central generating station of another type.

Engineering methods in the navy, like the engineers themselves, appear to be retired on account of age, so that the younger methods may have a chance. Thus we find that naval officers beginning their experience are eager to become acquainted with the new and fashionable methods of power generation and transmission, while they do not care to make the acquaintance of the older methods. The old, therefore, is neglected and receives no benefit from the better education of the young officers, while the new and more attractive method gets all the benefit of being cared for and nursed into efficiency by the brightest young men in the service.

Still, there must be more than outward attractiveness in any method of power transmission to secure its adoption and retention on board a warship where reliability and efficiency must ultimately decide as to what can remain and what must be replaced by something better.

In our investigation of the various methods in use we will consider not only what they at present are, but what they might be if all that is known in regard to them were utilised in the installation, and we will assume that,—

First, all operations on a warship requiring power can, with properly designed mechanism, be performed by steam direct from the boilers.

Second, all operations on a warship requiring power can, with properly designed mechanism, be performed by water under a high pressure, imparted to it by steam-operated pumps.

Third, all operations on a warship requiring power can, with properly designed machinery, be performed by air under pressure imparted to it by steam-operated air-compressors.

Fourth, all operations on a warship requiring power can, with properly designed machinery, be performed by electric motors, using a current generated in a central station by steam-driven generators.

The idea that each of these four methods was suited to some functions and not to others is the reason why mixed systems prevail on many ships, and how far the assumption that this is not the case can be maintained, will be the subject of our present inquiry.

Keeping to the order we have indicated, the application of steam direct to all purposes first claims our consideration.

In all of our war vessels steam is used direct on a large number of the auxiliary machines throughout the vessel, and in all of them, except those fitted with hydraulic steering gear, the steam is carried from end to end of the ship, the steam windlass being at the one end and the steam steering gear at the other, requiring two lines of steam heated pipe for the whole length of the vessel. Between these points, both on upper and lower decks, machines are operated by steam on all our ships. On the upper decks there are steam winches, steam windlasses, steam boat cranes, and steam ash hoists; and on lower decks, outside the engine and boiler compartments, there are steam ventilating fans, steam air-compressors for torpedo-charging, steam steering gear, and in some of the vessels, steam turning gear for turrets, and steam ammunition hoists.

We see no mechanical difficulty in the way of steam being applied direct to all auxiliary machinery. Its elasticity, it is claimed, renders it difficult to train heavy turrets by this agent, and we are satisfied that, to have full control of accurate movements of such heavy masses by steam, some very reliable controlling device must be introduced, and for this purpose we have been introducing into

recent designs a continuous and automatic hydraulic control, which should make all movements of a steam-operated turret as accurate as those operated by hydraulic motors.

Compressed air and electricity need to be controlled through an inelastic medium to the same extent as steam does, when applied to such work as moving large turrets.

Granted that steam is capable of operating direct every class of auxiliary machine on a warship, and seeing that it is on hand at all times and always ready, how comes it that on all of our ships this steam is converted into some other form of energy and in this new form is applied to certain operations that it might just as well be applied to direct?

Those who claim that steam should be converted into some other form of energy and distributed to the various machines base their claim on three points of advantage—safety, economy, and comfort. The presence of steam pipes in all compartments of a war vessel must be considered in connection with the business in which the vessel is to be engaged, and that is to fight. In action these pipes would all have to be open at least from the forward turret to the steering engines in the stern, and are more or less subject to damage. It would be difficult to over-estimate the loss which might result from a broken steam pipe in any compartment under the main deck of a war vessel in action. Such an accident might not only involve the loss of all men in such a compartment, but the total disablement of the ship as a fighting machine.

It is difficult to determine the relative economy of steam as applied direct throughout a ship, and as applied through some other agent. The great source of loss is through condensation. Nearly all the machines which use steam in naval vessels, outside of those directly connected with the propelling of the vessel, do so intermittently, and masses of metal must be heated up every time a movement is made. There is no doubt that a large portion of the steam used goes to renew lost heat in this way, and is condensed without doing any useful work; besides this source of waste, the steam engines used for auxiliary work are of necessity of the most wasteful character. As a rule, they are reversing, the reversing gear usually consisting of a reversing valve operated through some form of floating lever. The waste of steam in this class of engines is enormous, and we hardly think that on an average a horse-power is obtained for each one hundred pounds of steam used. The combined waste from condensation and wasteful motors must result in a large expenditure of fuel in proportion to the work done, and in our opinion makes the direct application of steam to auxiliary machinery on warships the least economical of the methods in use.

The objection to the direct use of steam on account of the discomfort caused by heat in places difficult to ventilate efficiently is, perhaps, the most serious objection made to this method of power distribution. Steam and exhaust pipes running to the various machines must be carried as a matter of safety below the protective deck line, and for the same reason all engines requiring to be operated in time of action are also placed below that deck, where ventilation is very difficult, even where there are no engines; but with steam engines in or under handling rooms, and in recesses formed in ammunition passages, and with battle hatches closed, it is difficult to see how men can possibly carry on the work of tending such engines, serve ammunition hoists, and perform all the duties required of the under-deck force in time of battle. Physical endurance has always been a prime factor in action, and no method of distributing power should be adopted in a warship which renders it impossible for every man to do his duty in the time of trial.

We may now consider our second assumption, that all operations on a warship requiring power can, with properly designed machinery, be performed by water under a high pressure imparted to it by steam-operated pumps.

The danger we pointed out from the

possibility of damage to a steam pipe where steam was used direct, does not exist in connection with hydraulic transmission, the result being simply cutting out of service the machine to which such a pipe leads. As to reliability, our experience proves that after the first difficulties are overcome there is no form of power transmission which can be depended upon with more confidence than hydraulic. At first particles of rust, scale, chips, etc., in the many connections of such a complicated system of distribution as would be required on a warship, coupled with defective material in parts, try the patience; but once these microbes are out of the hydraulic system, a long and useful life is pretty sure to follow.

Partial hydraulic systems are now on warships under the care of officers who have had no opportunity to become expert in hydraulic work, and who in many cases do not believe in its application, and yet the record of failure at any time to perform the functions required is a remarkably clean one; so, as regards safety, either to the system itself, the vessel as a whole in which it is installed, or the life of those connected with its operation, the hydraulic system of transmission is certainly superior to any method of direct steam application.

Granting that this system is eminently safe, is it an economical method of distribution?

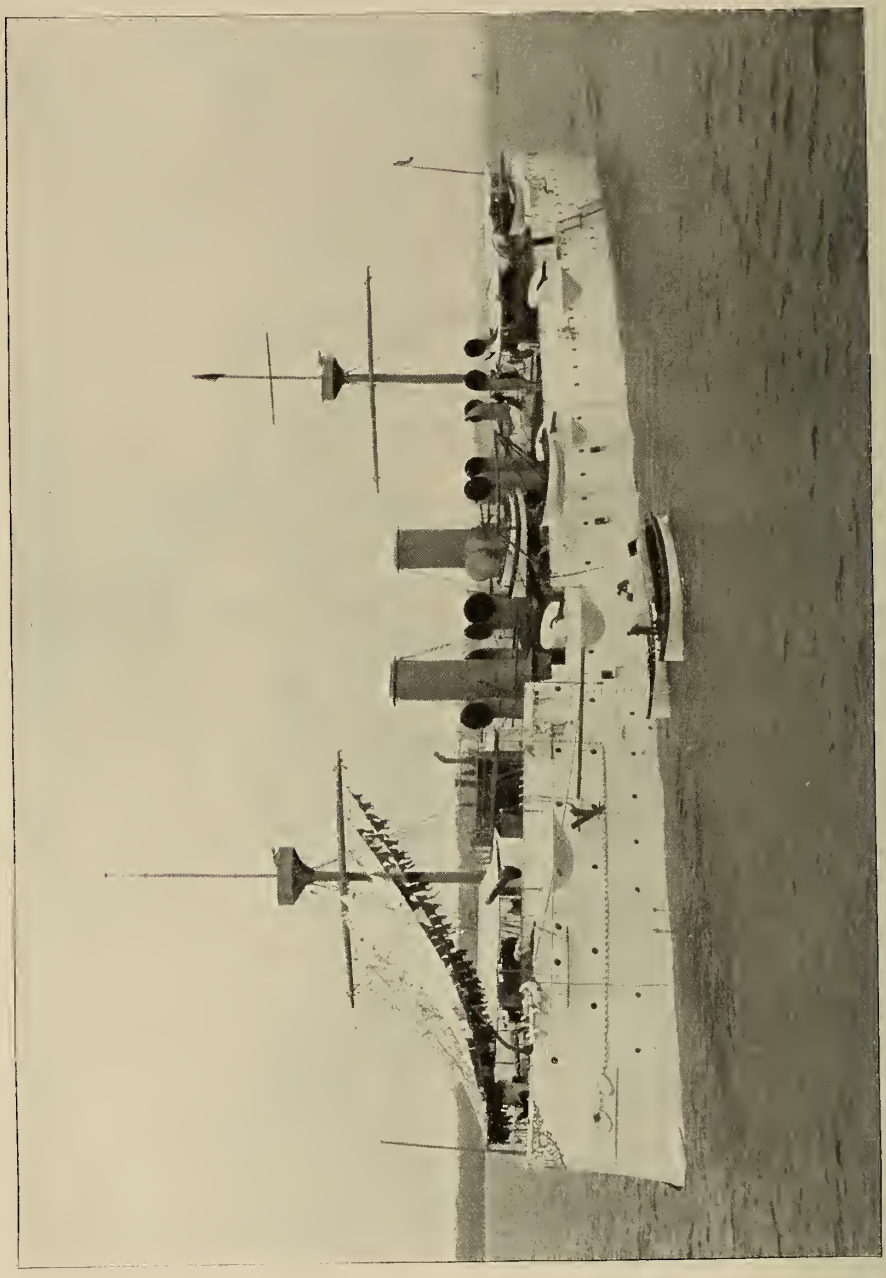
It has generally been allowed even by those who are most strongly in favour of its adoption that, owing to the conditions which govern the operation of most auxiliaries on board warships, economy must be sacrificed when a hydraulic system is adopted. Hydraulic motors for any of the varied purposes requiring power on warships must be designed large enough to meet the maximum requirements of the service, and if these motors are of the piston or plunger type, the regular form at present in use, the maximum amount of power will always be used, although the minimum work only is required.

If, instead of using a motor having cylinders with moving pistons or rams, utilising the pressure to obtain power, and measuring out a given quantity of water for each movement, irrespective of the work to be done, the pressure water was applied to a properly designed wheel of the tangential type, an efficiency averaging about 70 per cent. could be obtained with a great variation in the load, and thus one source of waste with this system would be avoided.

The direct ram would be still retained for certain purposes where precision of movement is of the first importance, such as in steering gears and gun-training movements.

The American mania for direct-acting steam pumps to generate power for such an installation is the most fatal obstacle to be encountered in any effort to reach reasonable economy in a hydraulic system of power transmission on board our warships. In some of the battle-ships now building it is proposed to install, for the generation of hydraulic power, say, six duplex hydraulic pumps of 400 gallons capacity each per minute, at 600 pounds pressure per square inch. This requires twelve steam cylinders, 22 inches diameter, and, say, 24 inches stroke, being with pump friction about 950 horse-power. This will require, with the type of pump proposed, not less than 95,000 pounds of steam per hour, and this certainly would give on the main engines 5000 horse-power. Half the total boiler power of the ship with forced draught would be absorbed by such a pump installation, if working at its full capacity. This is the main reason why hydraulic power is condemned. But there is no reason which we can discover why a hydraulic system of power distribution for all purposes requiring power should not be more economical than steam applied direct, provided ordinary steam pumps are avoided in the generating department, and something else than a water meter is used as a motor.

As to comfort, the presence of hydraulic pipes in any of the living spaces, store rooms, or magazines in no way affects the temperature or ventilation of such spaces. Branch pipes in very few



THE UNITED STATES CRUISER "BALTIMORE," ONE OF THE VESSELS WHICH TOOK PART IN THE BATTLE OF MANILA.

cases need exceed 1½ inches in diameter. Any leakage is easily discovered and can do no damage. The working of all water motors can be accomplished without noise, and, there being little or no change in the temperature, all joints when once tight are likely to remain so, and this is the one great comfort always attending a well-designed and carefully installed hydraulic system of transmission.

The third assumption, that all operations on a warship requiring power can, with properly designed machinery, be performed by air under pressure, imparted to it by steam-operated air-compressors, may now be considered.

This means of transmitting power in warships has been advocated at different times, and by men well qualified to give an opinion, and who have had opportunities to test partially its merits as against other methods. We have mentioned in this connection Colonel Soliani, chief engineer of the Italian Navy Department, who, in comparing the various methods now in use on board war vessels for transmitting power consisting of steam direct, hydraulic, compressed air, and electricity, sums up the advantages and disadvantages of these different methods by giving the preference to compressed air for all purposes except handling big guns and turrets, for which he would use hydraulic power.

As our aim would be to have on any given ship but one method of power transmission, we would not make any exceptions in regard to the operation of large guns or turrets.

Steam and electricity, when applied to handling large guns and turrets, have the same objectionable features as compressed air, combined with other objections peculiar to themselves. The objection to compressed air in this connection is its elasticity, preventing accurate movements being made with certainty. This can be overcome by the introduction of a continuous and automatic hydraulic control as mentioned in connection with the use of steam direct.

Granting, then, our assumption of the possibility of a compressed-air system of power on warships being made serviceable for all auxiliary purposes, we may now consider the qualities of safety, economy, and comfort in their relation to this system.

Perhaps no form of power transmission has all the elements of safety in the same degree as compressed air. A leak in the transmission pipes improves the ventilation and adds to the comfort of those working in that compartment. The pressure carried, of, say, six atmospheres, makes all kinds of connections simple and easily cared for. Double bottoms and difficult places of access can be purified and ventilated by a small jet from the distributing pipes. Water may be excluded from any damaged compartment which can be made air-tight down to the level of the opening that admits the water. The writer floated one ship, the *Jessie Osborn*, which was stranded on the rocks north of San Francisco Bay, when great sections of the bottom were entirely gone, by stiffening and caulking the hold deck, and by means of an air compressor forcing air under that deck, thereby forcing the water out through the open bottom, lifting the ship up to almost her light draught.

Any compartment in a warship using a compressed-air system of power transmission can be promptly cleared of water by this means, the extent of the aperture by which the water enters being of no consequence. This being kept in view in designing and building the vessel, would render this method of transmitting power one of the greatest elements of safety and give an immense added value to the under-water compartments; so that, should one or more compartments be damaged by either striking a rock or being struck by a torpedo, such compartment would simply be put out of use, but by keeping it charged with air to a pressure equal to the draught of water of the vessel, its buoyancy would not be impaired if the damage was in the bottom, as it most likely would be.

We have mentioned this advantage in the use of compressed air because it

is the only one of these three systems of power transmission which can be so used in connection with the general safety of the vessel.

In the matter of economy, both in generating and in distribution, the compressed air, if proper methods are adopted, should be at least equal to any of the other systems which have been tried. The compressors used should be of the most modern type—triple expansion of steam and triple compression of air, and with storage enough to meet sudden calls.

With the most economical steam-engine, operating the most economical compressor, and the compressed air converted into useful work through economical air-motors, compressed air power transmission on warships should meet every requirement on the score of economy.

As to comfort, we have already pointed out some of its advantages. No return pipes are required, as in all other systems, electricity not excepted. The liberated air from motors will ventilate and cool the spaces in which they operate, and these spaces are usually the most difficult to ventilate.

In the hydraulic system all losses by leakage must be made up by fresh water manufactured on board, whereas by this system the more loss the better it feels where the loss has occurred, and the feeling of absolute safety in case of any break in the transmission pipes must add to the efficiency of the men whose duty requires them to work beside the motors and the pipes which supply the power to them.

All the machinery required in such a system of transmission is of a character now well understood by the engineer officers on warships, and the difficulties attendant on operating mechanism not understood by the operator is avoided.

The fourth assumption, that all operations on a warship requiring power can, with properly designed machinery, be performed by electric motors, using a current generated in a central station by steam-driven generators, now remains to be considered.

The advocates of this system have a foundation for their method of power transmission which those who favour any of the other methods do not possess, in the fact that all modern warships have a certain amount of power converted into electric energy and distributed throughout the ship for lighting purposes.

While there is no difficulty in generating electricity by the use of water or air motors, there is the waste of converting the steam into one form of energy and converting that again into another form of energy. To justify such a course, it would be necessary to prove that water or air as a transmitting agent possessed, for all purposes but lighting, a great advantage over any known method of electric transmission.

This, in the present condition of the art of transmitting power by generated electricity, cannot be maintained. We must therefore concede that the electric method has the advantage of undisputed possession of the field for at least one part of the work to be done.

Another advantage which electricity possesses, here as everywhere else in the field of applied mechanics, is that young engineers are educated into the knowledge of how best to generate and apply this agent in a manner which has never been thought necessary in regard to other forms of stored-up energy, and, it being the fashionable agent for power distribution throughout the engineering world, its development is one of the modern wonders of engineering.

An electric installation for all power purposes on board warships will, on account of the education of the engineers or other officers in charge, receive more intelligent care and more skilful application than any of the other methods here considered. While this advantage is not inherent in the system itself, it is of the utmost practical importance in its successful application.

The transmitting wires of the electric system possess a flexibility which cannot be claimed for the pipes of the other systems. This is an important advantage in the crowded compartments of a warship.

As to safety, economy, and comfort,

we may now consider these in comparison with other systems. In regard to safety, we might safely take it for granted that whatever disturbance would fracture the pipes of an air or water system would part the wires of an electric system. In that case the danger to life and also to the ship would be far greater with the electric system than with the others. Automatic safeties could be applied to almost any conceivable extent against such accidents, yet, where safety devices are needed, the system cannot be so safe as where no safety devices are needed.

There is also a growing fear amongst marine engineers that certain materials are rapidly destroyed by electric action, caused by the hull of the vessel becoming magnetised in some way not yet fully understood. It is claimed that vessels fitted with electric generators develop rapid deterioration in all sea-water pipe connections. Whether sufficient reliable data have been collected, either to establish or refute this claim, is, we think, doubtful. It is a question which ought to be most fully investigated. At present it is simply a matter of conjecture, and to marine engineers a matter of considerable uneasiness.

As to economy, the electric generating plant has been developed both electrically and commercially into a high degree of efficiency. Direct-operated generators are now driven by engines of the most highly developed type. These engines are so perfectly controlled by automatic governors that full load or no load may be the condition without apparent change in the working of the steam motor.

The generators may be so divided into units as to meet the conditions of work at any time without much of the steam-engine power running without load. Lighting and power can be taken from the same installation, thus effecting a saving in the labour of attendance. There is no doubt that the economy of generating the power electrically will be better than with either water or air, owing to the high speed of the engines and the small amount of loss in the generating mechanism.

In regard to the distribution, the losses, by careful installation, can be reduced until they shall at least not exceed the losses of friction in either air or water pipes of the other methods. Careful designing may also reduce the losses in converting the electric energy into mechanical movements, so that the economy of this part of the system may be better than in either air or water motors. All this class of work has been so perfected that every function requiring power on a warship can be performed by electric motors, without involving the use of anything except well known and tried mechanism.

AERIAL TORPEDOES.

By Hudson Maxim.

THE U. S. FLAGSHIP "OLYMPIA" AT MANILA.

THE chief questions involved, not only in warfare, but in daily life everywhere, of both men and other animals, are those of offense and defense, attack and resistance, or counter to attack. This race between offense and defense has resulted in the development of cannon of comparatively small calibre, but with great thickness of wall and tremendous weight, in order to withstand the enormous pressures necessary to impart requisite velocities to long and heavy armour-piercing projectiles. Powder space within the armour-piercing shell has been sacrificed to weight and strength of metal, reliance being mainly placed upon the smashing effect of a huge bolt of steel. Opposed to this we find the modern battle-ship clothed in a wall of steel so ponderous as to reduce mobility to a minimum.

We find in history something like a parallelism with this before the invention of firearms, when warriors clothed themselves in armour, which was constantly increased in weight and strength, to resist penetration of improved weapons. However, upon the advent of firearms all armour was cast off, for it was found impracticable for an individual to carry sufficient armour to withstand the penetrating force of missiles hurled by gunpowder, and resistance to penetration was wholly sacrificed to mobility.

Nature teaches us many lessons, and she is often able to show us how to do many things in the best possible way. A counterpart of many great inventions are to be found in nature. The screw propeller ought to have been suggested much earlier than it was by the tail of certain fishes moving back and forth in half turns. The bilge keel has always been very popular among fishes. The first Whitehead torpedoes were made tapering nearly to a point forward, but experiments have shown the advantage in making them largest in cross section near the forward end. A study of the fish creation might have taught this without resorting to experiment. Every imaginable form that animal life could take, it appears to have taken, and every imaginable thing that Nature could make animals do, they appear to have done in the struggle for existence.

We are not confined entirely to the results of experiments made by man in order to judge of the efficiency of the heavily armoured battle-ship and kindred craft, as compared with the small, unprotected and fleet cruiser, armed with weapons capable of inflicting the maximum of destructive effect, but may learn something from Nature. The first steps taken in nature for the protection of animal life were to cover animals with armour, but the dominant types, which have been evolved by the fierce struggle for existence through countless ages, are not the armour-clad oysters, lobsters and reptiles, but the agile, unarmoured carnivorous cruisers, and the fleet-footed herbivora, and, above all, man, who owes his position in nature, not to the thickness of his skin, but to his mobility and intelligence, enabling him to avoid danger, and at the same time strike heavier and more effective blows than any of the brute creation.

Similarly, with the advent of a system of throwing high explosives, in sufficiently large masses to render armour absolutely useless, we shall find navies discarding their armour, and everything will be made subservient to speed and mobility. This will work a complete revolution in the construction of ordnance and ships-of-war. Heavy ordnance, instead of being made, as at present, of small calibre, with thick and heavy walls, will be made of much greater calibre, and with comparatively thin walls. The projectile which will then be employed will be a thin shell, simply thick enough to support the mass of contained explosive in its flight from the gun; and the explosive will be sufficient in quantity to work infinitely more destruction upon any target than such projectiles as are at the present day thrown from heavy guns.

One of the requisites of primary importance to a system of successfully throwing high explosives in large masses, lies in the propelling charge,—a suitable gunpowder,—one which shall give a sufficiently low initial pressure, and maintain that pressure behind the projectile in its flight throughout the entire length of the gun, and a powder which will, with absolute certainty, burn alike at all times under like conditions, in order that predetermined pressures and velocities may be depended upon.

The Maxim-Schupphaus multiperforated smokeless cannon powder has been made commercially during the last five years and tested extensively by the United States government, and has finally been adopted by the army. It is a modification of the Maxim Schupphaus multiperforated cylinder that the writer proposes to employ as a torpedo powder for throwing high explosives from ordnance.

Smokeless powders are consumed entirely by surface combustion, and it is obvious, therefore, that if one powder presents, pound for pound, a smaller combustion area to the flame of ignition than another, its combustion will exert correspondingly less initial pressure. The Maxim-Schupphaus smokeless torpedo powder presents only one-sixth the area of combustion to the flame of ignition that is presented by cordite. It, therefore, cannot give more than one-sixth the initial pressure under like conditions. As variations in pressures and velocities are also in direct ratio with initial burning areas, the torpedo powder having only one-sixth the area and being consumed under one-third the pressure, can vary only about one-eighteenth as much as cordite under the same conditions.

The illustration on the next page is reproduced from a photograph of some unburned and partially burned grains of the Maxim-Schupphaus smokeless cannon powder, originally taken for the London *Engineer*. When grains of this powder are fired in a gun too small to effect complete combustion, some grains which leave the gun end-on, at high velocity, are extinguished by the rush of cold air through the perforations.

The grain at the top and left is a cylinder having nineteen angular perforations, so disposed with respect to one another that when the combustion within them has progressed so that they have become tangent, or intersect with one another, the grain is simultaneously completely consumed. This is the preferable form of grain. The grain lying next to the right is the same as the first, but is partially burned, and illustrates beautifully the action of combustion, and that it progresses in the manner and with the effects claimed. The remaining grains illustrate other forms, unburned and partially burned, and which are not adapted to produce the high ballistic results attainable by the first mentioned grains.

It is popularly supposed that the chief consideration involved in throwing high explosives from ordnance is the danger of their premature explosion in the gun due to the shock of acceleration. But this is not the case. The most powerful of high explosives, namely, wet guncotton and picric acid, known also under the names of lyddite, emmensite and melinite, are already successfully thrown from high-power

guns at the highest velocities. Now, as it is the length of column of explosive in a shell which endangers it from the shock of set-back or acceleration, we may increase the size of the projectile in cross-section indefinitely to provide greater space for explosive

to thirteen miles, according to the length of the gun, the weight of the shell and the character of the propelling charge. Now, as the energy imparted to a shot depends upon the amount of pressure per square inch exerted upon its base through a given distance, it is obvious

UNBURNED AND PARTIALLY BURNED GRAINS OF SMOKELESS CANNON POWDER.

without adding in the least to the danger from shock in the gun. As the column of explosive in the 24-inch aerial torpedo proposed by the writer, and carrying half a ton of picric acid, is not any longer than the column of high explosive now safely thrown in 12-inch shells, and as the writer employs the same kind of explosive, and as, further, the aerial torpedo will not be subjected to as high initial shock of acceleration, the half-ton aerial torpedo will be even safer to throw than the 12-inch shells now generally used by all the great powers.

The present 12-inch gun weighs about 50 tons, and is adapted to stand an initial powder pressure of about 35,000 pounds to the square inch. But this rapidly falls off toward the muzzle, making the average pressure a little over 20,000 pounds. The 12-inch projectile weighs from 850 to 1000 pounds, and carries from 75 to 100 pounds of explosive. The shells have a velocity of from 1900 to 2300 feet per second, and a range from ten

that 10,000 pounds to the square inch exerted upon an area of base four times as great and maintained through a distance 25 per cent. longer must impart a much greater muzzle energy than can be imparted with a pressure of 20,000 pounds per square inch exerted upon an area one quarter as great for three-quarters of the distance.

With the advantages of greater length of travel in the gun, greater area of base, and better maintained powder pressure, we are enabled to impart to the 24-inch aerial torpedo a very much greater muzzle energy than is imparted to the 12-inch shell thrown from present ordnance.

Now, as with the same muzzle energy a projectile of twice the weight will be thrown at about three-quarters the velocity and range, we are enabled, with the advantages just mentioned in favour of the aerial torpedo gun, to throw a projectile weighing three times as much as the 12-inch shell, at more than three-quarters the velocity and range. Such

a projectile will consist of a ton of steel and half a ton of high explosive. The one system is as safe as the other; the one projectile may be substituted for the other; the only question involved is whether a projectile, weighing 850 pounds and carrying only 75 pounds of explosive, is as destructive a missile as one weighing a ton and a half and carrying half a ton of high explosive. Is the 25 per cent. greater velocity of the 12-inch shell advantage enough to counterbalance the tremendous additional weight of metal and explosive of the 24-inch aerial torpedo?

The system involves no radical departure from the present forms of ordnance. The aerial torpedo gun of 24-inch calibre will weigh the same as the present 12-inch gun, and will have substantially the same outside dimensions, except being a little larger toward the muzzle and a few feet longer.

The aerial torpedo or projectile which will be thrown involves nothing questionable or intricate in its construction, and no new or untried law. It is built on known lines, based on demonstrated physical laws.

The following, from the April number of the *Journal* of the Royal United Service Institution of Great Britain, and which originally appeared in the London *Engineer*, will give an idea of what is already being done in the way of throwing high explosives from ordnance in present forms of shells. The quotation relates to some experiments upon the old British battle-ship *Resistance:*—

"The between decks is a sight never to be forgotten. Framing, splinter screens, partitions, and bulkheads have been rent into fragments by the bursting of the high-explosive shells, whilst grim splashes of a yellow substance that has marked the places where shells have burst outside the plating betoken the character of the explosive employed.

"It is now an acknowledged axiom that high explosives will be employed in shells. Whether naval officers object to carry them on board ship or not, they will, in future, be the principal ingredient by which shells are filled for coast and siege purposes; and already the nature of high explosives, to be used as a 'service' bursting charge for high-angle howitzers in coast and siege batteries, has been practically determined.

"After exhaustive trials, all inventions in this direction, except wet guncotton and lyddite (picric acid), have been discarded. A satisfactory high explosive has been defined as fulfilling the following conditions:—It should be safe in manufacture, store, and transport, and stable under service conditions. It should be of a convenient form for filling shell, and safe to manipulate in the process. It must be capable of standing the shock of discharge in high-velocity guns, and must, on striking, detonate with violence and certainty, and without the aid of any dangerous fulminate. The explosive should be capable of having its sensitiveness increased or diminished as occasion may require, and a shell, when filled with it, should not detonate when hit by another shell.

"Of those high explosives experimented with, the two coming nearest to the standard are wet guncotton, which has been adopted by at least one European power, and lyddite, which is used in our Service. Wet guncotton will not detonate in a shell struck by another shell, and in this respect is more satisfactory than lyddite; but guncotton, to produce its best effect, must be compressed into discs to fit the interior of the shell, and the shell must, therefore, be made in two parts and screwed together,—a source of weakness and possible danger. Dry cotton and a fulminate are, moreover, required to detonate it. Hence lyddite, to which none of these objections apply, will probably be adopted as the high explosive of our Service."

Naval authorities must soon give due consideration to the aerial torpedo. From half a ton to a ton of high explosives can certainly be thrown with absolute safety and great accuracy at all fighting ranges at sea, and if such quantities of high explosive, striking and exploding on board a battle-ship by impact upon its superstructure, will destroy the vessel or throw it out of ac-

tion, or if such quantities, when projected into the water and exploding as submarine mines adjacent to the hull of a battle-ship, will suffice to blow her up or sink her, then the first shot of the aerial torpedo gun proposed by the writer will render obsolete every battle-ship in the world.

Immense sums of money will no longer be expended in armoured protection which will not protect, and in the construction of huge and ponderous fighting machines whose very size renders them a more easy prey to the torpedo gun than a small and light cruiser, simply big enough to provide a portable and stable gun platform. If a projectile can be thrown which shall be sufficiently destructive to demolish anything and everything it hits, then, obviously, thereafter centralisation of men and expense must be abandoned and men and weapons must be dispersed in order to form as many and as small targets as possible. Navies must fight in skirmishing order, exactly as armies on land now do.

If the battle-ship, forming a target ten times as great, offers no greater protection against the aerial torpedo than the small, unprotected cruiser, and costs ten times as much and carries ten times the number of men, it is certainly not more than one-tenth as efficient a fighting machine. Anything revolutionary in character, however meritorious, always has a hard fight for recognition, especially in overcoming the opposition backed by enormous vested interests. It would be easier with a few cruisers armed with aerial torpedoes to make a scrap heap of every battle-ship of the combined navies of the world to-day than it will be to even secure the system a place for once in the line of battle.

If there is even a fighting chance for the aerial torpedo to work the revolution in naval construction which the writer predicts, then this matter is a subject for serious consideration, especially by the United States government before making the enormous expenditures in battle ships which Great Britain has made. Half a million dollars will build and arm a light torpedo cruiser which will carry one 24-inch torpedo gun and two torpedo mortars. This will demonstrate the efficiency of the system. If it fails, it costs but five hundred thousand dollars; if it succeeds, it will save five hundred millions. The battle-ship must go.

The great distance to which enormous quantities of high explosives may be thrown by torpedo guns and mortars and the hitting qualities of these weapons, when the enormous size of the target is taken into consideration within whose area a torpedo, striking, will destroy a warship, renders these weapons of supreme importance for coast defense.

Aerial torpedo guns when once successfully tried, either on land or sea, will cause a revolution in coast fortifications as well as in war vessels. Aerial torpedoes penetrating deep into earthworks before exploding will be disastrous. It will then be the weapon, rather than means of protection, that will be the dominating factor in both attack and defense. The cost by present methods, in ammunition and wear and tear of guns in bombarding coast fortifications or towns, is quite equal to the amount of damage done. This will all be changed by the introduction of aerial torpedoes.

TORPEDO-BOAT DESIGNS.

By Assistant Naval Constructor H. G. Gillmor, U. S. N.

THERE is nothing more promising of instructive and interesting developments in modern naval warfare than the torpedo-boat. Since its first appearance, in crude form, thirty or more years ago, it has gone through rapid and startling transformation, from the open rowing boat with its spar torpedo, to the swift and highly-powered vessel of the present day, carrying explosive bombs of self-propelling character. In discoursing on the subject at the last meeting of the Society of Naval Architects and Marine Engineers, Assistant Naval Constructor H. G. Gillmor, of the United States Navy, presented some facts which are, in part, reproduced in the following pages. They are particularly interesting at the present time, when opportunity may come at any moment for actual torpedo-boat exploits in the conflict between Spain and the United States.—THE EDITOR.

The torpedo as an offensive weapon made its appearance during the American War of the Rebellion, from '60 to '65, and, by its achievements during that war, established itself as a factor to be considered in naval warfare. So many and so brilliant were the successes which were achieved through its use in this war that it was almost immediately taken up by the maritime powers of Europe and became a recognised naval offensive weapon.

The torpedo of that time was the spar-torpedo, which, being carried at the end of a spar, twenty to twenty-five feet long, capable of being rigged out and in, and placed at various angles, could be brought in contact with the bottom of the enemy's vessels by a pulling boat or a steam-launch and discharged by means of an electric connection. For success it was necessary

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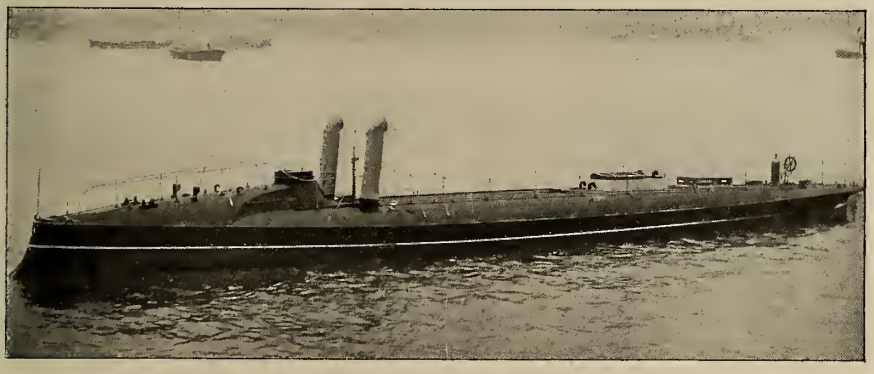
A STRING OF MODERN TORPEDO BOATS.

A TORPEDO BOAT UNDER THE SEARCHLIGHT.

to come alongside the enemy before discovery and disablement. The rapid-fire gun of small calibre and the search-light were not then in existence, so that the task of the torpedo in the hands of fearless men was, on a dark and foggy night, less impossible than might be thought.

For some years the torpedo remained as it was at the close of the war,—the weapon of the regular pulling boats and steam launches of the man-of-war. Boats which in time of peace did duty as the regular running boats of the ship, were provided with apparatus for the use of the spar-torpedo in time of war as a part of their equipment. Early in the seventies it was proposed to construct small special steam vessels, in which a lightness of hull, fineness of lines, and exceptionally large motive power would ensure a speed of from 15 to 18 knots, for use as torpedo-boats. A little before this the Whitehead torpedo had been introduced and was being experimented with by all the European powers. It was destined to revolutionise ideas of torpedo warfare and make more necessary the construction of the special torpedo vessels then proposed.

It is in Great Britain, in the yards of Messrs. Thornycroft and Yarrow, that special torpedo-boat construction was begun, and it is there that the torpedo-boat has become the very high-speed vessel that we possess to-day. The rivalry which has existed in the first instance between these two builders, and later among an increasing number of builders, has had quite as much to do with the development of the present types of torpedo-boats as have considerations of their warlike purpose and efficiency as means of offense. We are to-day accustomed to hear torpedo-boats spoken of as "20 knotters," or "30-knotters," as if speed, regardless of size, cost, number of men involved, offensive power, etc., were the one consideration in such vessels; and there is no doubt that in the popular mind a 30-knot boat must be far superior to a 20-knot or a 24-knot boat, no matter what may be the relations existing between other qualities of the two boats.



THE RUSSIAN "BATOUM." THE FIRST SEAGOING TORPEDO BOAT. BUILT BY MESSRS. YARROW & CO., LTD., LONDON.

Messrs. Thornycroft built, in 1873, at their yards in Chiswick, to the order of the Norwegian government, the first special torpedo-boat constructed. This vessel, which was subsequently named the *Rasp*, was 57 feet long, 7 feet 6 inches beam, with a displacement of about 7½ tons and a speed of about 15 knots. She was originally provided with an apparatus for the towing torpedo. France began, under the programme of January 30, 1875, the construction of torpedo-boats subject to the following limitations:—Length about 20 meters (75.6 feet); hull of steel capable of resisting musket fire; maximum speed, 14 knots; sufficient coal for eight hours at full speed. The United States

government, in 1876, ordered a large wooden launch, the *Lightning*, of the Herreshoff Manufacturing Company. She was 58 feet long; was fitted with spar-torpedoes, and made about 17.5 knots on trial.

In 1877, the *Lightning*, the first British torpedo-boat, was delivered by Messrs. Thornycroft to the British government. She was 85 feet long and 11 feet beam, with a displacement of 27 tons, and made 19 knots on trial. The same year, the Russian government had no less than 100 boats of a similar character under construction by different firms. These boats were 75 feet long, 10 feet beam, with a speed of 18 knots. Italy followed the next year with a vessel very much like the *Lightning*. About the same time the first German torpedo boat was constructed. It was rather larger than the British and Italian boats. By the end of 1878 the torpedo-boat had a place in the navy lists of the European powers.

About the time of the beginning of the construction of special torpedo-boats, the Whitehead torpedo had made such progress as to find some advocates for its use. From the uncertainties attending the action of the early automobile torpedo and the demonstrated efficiency of the spar-torpedo under the existing conditions, the latter was in many instances preferred to the former, and most of the early torpedo-boats were originally provided with spar-torpedoes and later fitted for the use of the automobile torpedoes. The introduction of the rapid-fire gun was the death-blow of the spar-torpedo and emphasised the necessity for high-speed torpedo vessels for use with the automobile torpedo. The torpedo itself, and the means for firing it, were rapidly improved. The growth and improvement in the torpedo-boat more than kept pace with its principal weapon.

From 1878 on, the work of construction of special torpedo vessels by the European powers has gone on steadily, although, in the case of individual nations, there have been delays from indecision as to the types which should be taken up. An enlargement in the sphere of the torpedo-boat, by which it was to prove its title to consideration as a separate branch of navies rather than one of the weapons of ships, was marked by the construction of sea-going tor-

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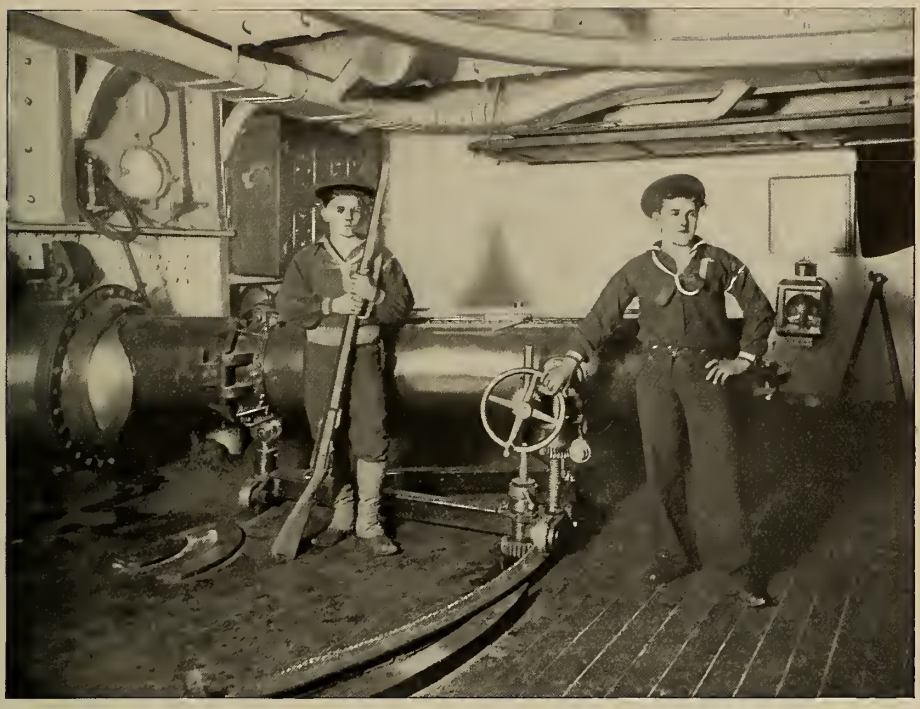
THE UNITED STATES TORPEDO BOAT "ERICSSON."

pedo-boats, of which the *Batoum*, completed in 1879 for Russia, was the first.

The purposes for which we require torpedo-boats naturally divide them into two large classes—the sea-going and the harbour or coast-defence. This division, while not directly recognised in the classifications of torpedo-boats



A TORPEDO TUBE.

by the various nations, is accepted in the division of duties to which boats already constructed are considered assignable, and is implied in all the classifications. The characteristics of the boats for the two purposes are essentially as different as are the characteristics of the sea-going battle-ship and the coast-defense monitor. To obtain the best results the natural division should be recognised and boats designed and constructed to meet the requirements of service in each class.

THE SEA-GOING TORPEDO-BOAT.

It is imperative that the sea-going torpedo-boat shall be seaworthy—that is, capable of remaining safely at sea in all such weathers as may reasonably be anticipated. Since the size of the boat has so vital a bearing upon its efficiency, it is important to consider what limitations are placed upon size by the necessity of seaworthiness, in order that it may be determined whether the size of boat consistent with the other characteristics required is consistent with this demand. In 1879, the Russian torpedo-boat *Batoum* (length 100′, beam 12′ 6″, displacement 50 tons) made the voyage from London to Nikolaief, a distance of 4800 miles, with a crew of three officers and nine men, at an average speed of 11 knots. In the following year, four boats for the Argentine Republic, of the same length and slightly less displacement, made the voyage from Plymouth to Buenos Ayres, under sail, with little difficulty, one of the boats requiring 72 days for the passage. Regarding the qualities of these boats, the captain who had charge of two of them in going out, wrote the builders, saying:—"I have no hesitation in saying that their sea-going qualities are exceptional. On both voyages we encountered very rough weather, and in the case of the *Brazilian* we were laid off Cape Frio in a heavy S. S. W. gale of such force as I have not experienced

THE BRITISH TORPEDO-BOAT DESTROYER "HAVOCK."

the like in twelve years, and she behaved admirably."

In 1890 the British boats No. 61 and No. 62 (length 125′, beam 13′, displacement 75 tons), convoyed by the storeship *Tyne*, made, under their own steam, the voyage from Plymouth across the North Atlantic, encountering severe gales, fog and icebergs. Since that time boats of about the same size have been sent by the British naval authorities under their own steam from Great Britain to their naval stations in Australia, Hong Kong, Singapore, India, and the Mediterranean. Boats for Japan, China, and South American States have made the voyages from European yards at which they were built to the ports of the countries to which they belong.

During the Japan-China war, sixteen of the Japanese torpedo-boats operated continuously, both independently and in conjunction with the fleets, as was required, and did efficient continuous service, under war conditions, during the months from August, 1894, to April, 1895. From the most reliable information obtainable, these boats were, with the exception of the *Kotaka*, 120 feet long by 13 feet beam, with a displacement of about 75 tons. These and other examples which might be cited prove beyond a peradventure the possibility of constructing boats of 100 feet or longer, which shall not only be capable of remaining at sea in all weathers, but which shall, more than that, be capable of making voyages of long distance at fairly constant cruising speeds.

Much is heard of the hardships of the crews of sea-going torpedo-boats and

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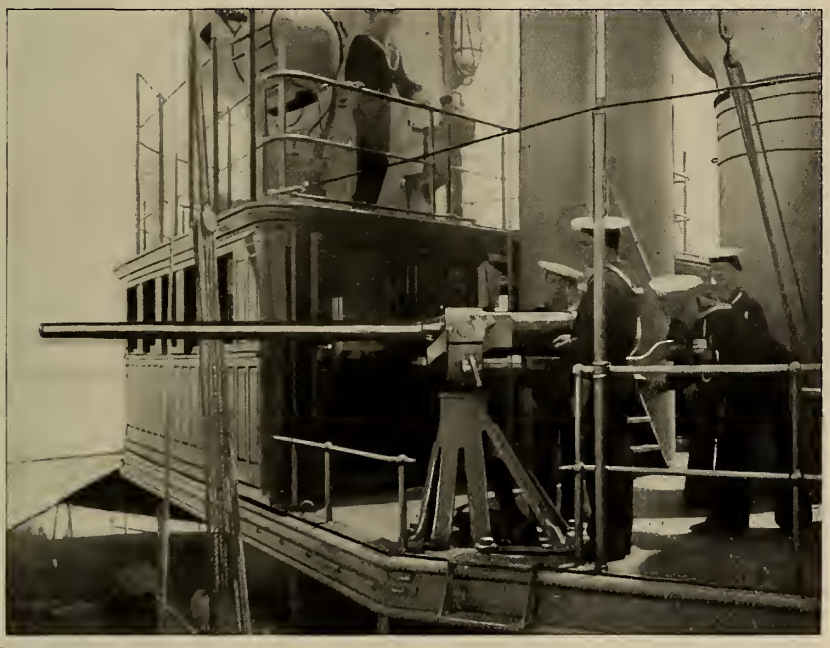
THE UNITED STATES TORPEDO-BOAT "CUSHING."

of the impossibility of their long sustaining the fatigue of the life. The remedy for this must lie in special training of men for this service. So long as the torpedo-boat is seaworthy, there can be no question of the possibility of men living safely and comfortably on board, when once they have become accustomed to the life. It is to be expected that men whose service has been in ships of large displacement or in torpedo-boats in sheltered waters should be incapacitated when first they encounter unusually rough weather in torpedo-boats.

The size of the sea-going torpedo-boat may then be fixed by the considerations as to the qualities which it is desirable to embody in its design, with the certainty that, due regard being had for stability, it may be made seaworthy and habitable so long as the vessel determined by these considerations is not less than 100′ in length and 50 tons displacement. What are these qualities, what values do our needs assign to each, and what manner of boat is it to which a rational consideration of these will lead us?

The sea-going torpedo-boat must be prepared to perform two kinds of duty. It must be capable of making a torpedo attack upon the ships of the enemy, and must be prepared to stand guard over and protect from torpedo-boat attack the ships of its own side. To fill both these rôles, it is necessary that it shall possess the following features:—

1. An efficient torpedo armament.
2. A gun armament sufficiently powerful for an attack upon other torpedo-boats.
3. High speed.
4. Sufficient coal capacity.
5. Good manœuvring qualities.



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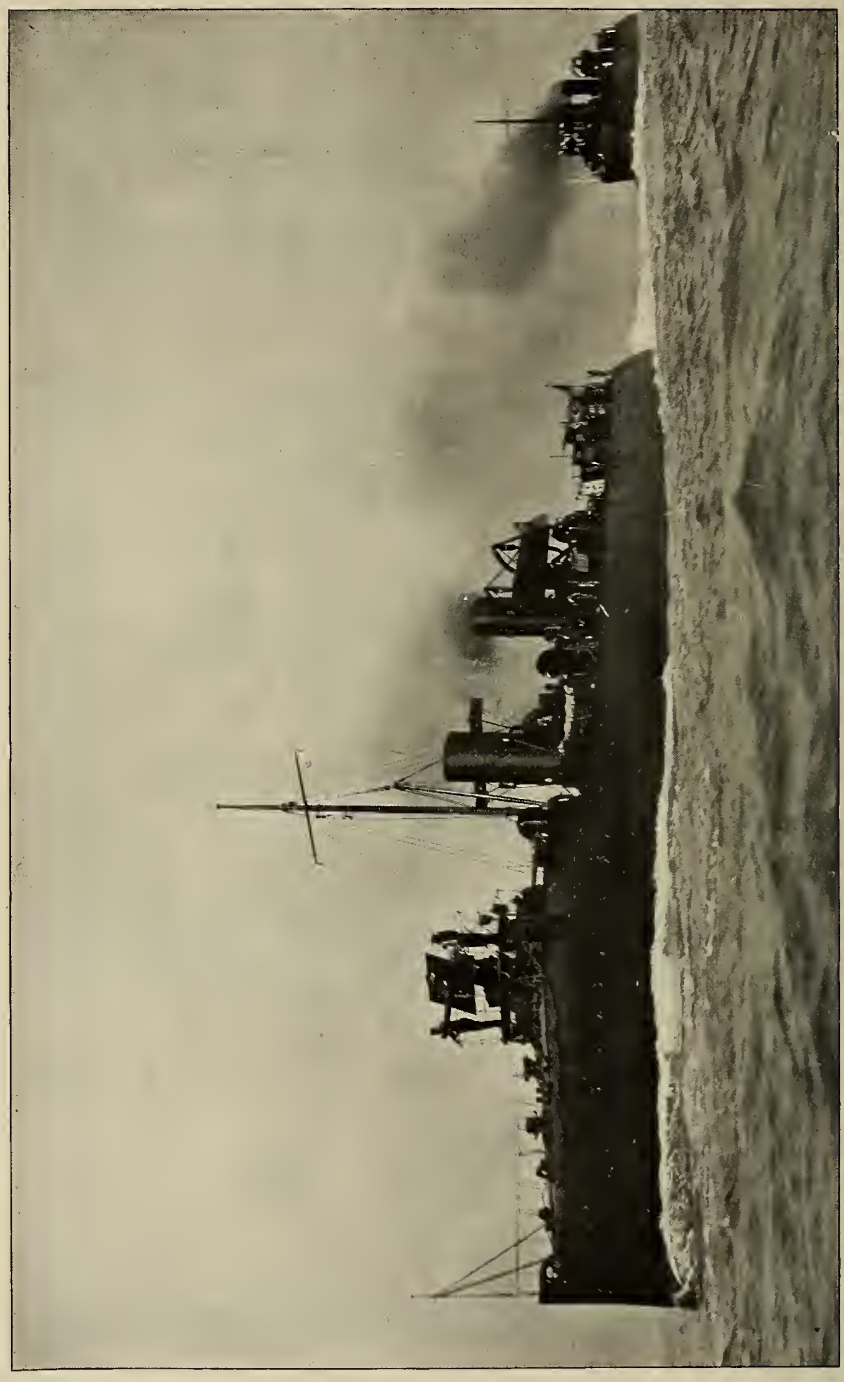
GETTING READY FOR A TORPEDO-BOAT ATTACK.

Torpedo Armament.—Torpedo experts are agreed that the long, 18″ torpedo is the most desirable for this purpose. There remains to be considered the number of tubes which should be installed. The bow tubes which were at one time generally fitted have been abandoned on account of the interference of the bow wave with the tube and



THE BRITISH TORPEDO-BOAT DESTROYER "BOXER," RUNNING AT 23 KNOTS. HER HIGHEST SPEED IS OVER 29 KNOTS.

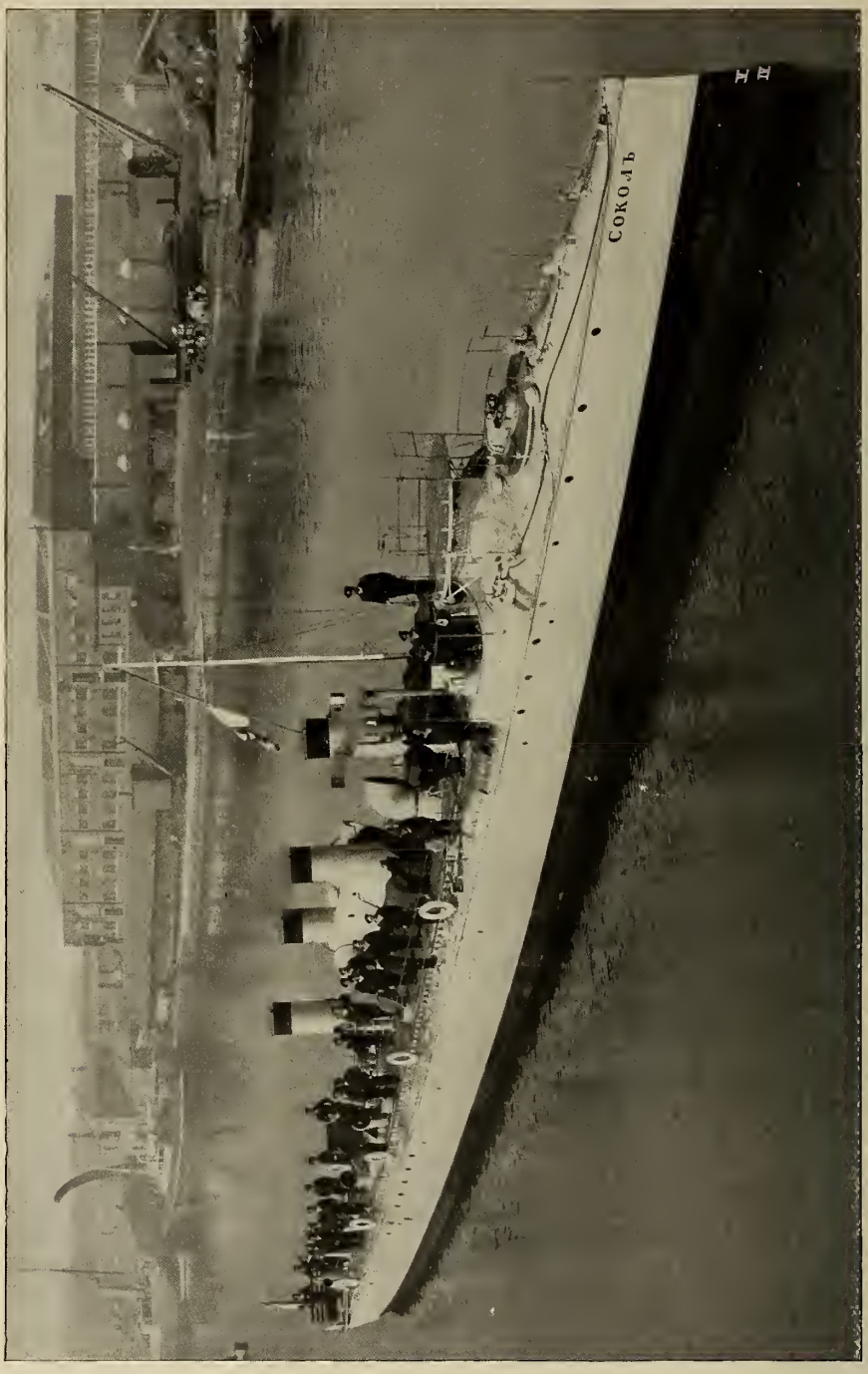
on account of the higher-speed boats running down the torpedo before it could gather way after being fired. Upon British, German, Italian, Russian, and United States first-class boats three training tubes have generally been installed. The Austrian, French, and Spanish boats of the same class, the British torpedo-boat destroyer and the German division-boat have but two each. There is very little experience upon which to base conclusions as to the necessary number of tubes. Provision for three torpedo tubes with a torpedo for each, and for carrying two additional torpedoes, is in conformity with the views of the greater number of the progressive maritime powers.

Gun Armament.—The boat requires to be provided with an armament which will enable it to encounter and disable or turn back a boat attacking vessels over which guard is being kept. The 1-pounder gun has been shown to be incapable of stopping a torpedo-boat. The 3-pounder, possessing greater penetration and mining power, will. The guns and the torpedoes will not generally be used at the same time. It is believed that three 3-pounder guns would make a battery which could be manned by the crew of the torpedo-boat, and which would be sufficiently powerful for its purpose.

Speed.—High speed is necessary in the sea-going torpedo-boat to make it meet three important conditions. The first is that it shall be in a class by itself, capable of refusing engagement with vessels of any other class than its own. The second requires that it shall be capable of approaching and getting away, in a torpedo attack upon ships, with sufficient rapidity to make the attack a success. The third condition is that when standing guard over ships to protect them from the attacks of torpedo-boats it shall be capable of pursuing and engaging these boats. The speed of the fastest cruisers of the world, attained only by a very limited number, is 22 knots, so that a speed in excess of this is required in the sea-going torpedo-boat in order to meet the first condition.

A TORPEDO-BOAT DESTROYER READY FOR LAUNCHING IN THE YARD OF PALMERS SHIPBUILDING AND IRON COMPANY, LTD., JARROW-ON-TYNE, ENGLAND.

The experience upon which to base



THE RUSSIAN TORPEDO-BOAT DESTROYER "SOKOL," AS SHE APPEARED WHEN ON THE POINT OF LEAVING ENGLAND FOR RUSSIA. BUILT BY MESSRS. YARROW & CO. LTD., LONDON.

the limit of speed required by the second condition is not great. The *Almirante Lynch* and the *Almirante Condell* attacked and torpedoed the *Blanco Encalada* without requiring the full 20 to 21 knots of which they were capable. The maximum speed of the Japanese torpedo-boats which operated very successfully during the Japan-China war was 23 knots, and upon two occasions these successfully attacked and torpedoed vessels of the enemy. There seems reason to believe that the speed fixed by the first condition is not too low to be consistent with the second. The third condition requires a consideration of the boats with which sea-going boats may be expected to contend. Of the more than sixteen hundred serviceable torpedo-boats which are now possessed, are building, or are projected by the nations of the world, there are but 260 having a speed of more than 25 knots. Of these, 153 are of the large size and high speed known in the British service as torpedo-boat destroyers, and 87 more are credited with a speed of but 26 knots. It is believed, therefore, that a speed of 26 knots would be sufficient to make a sea-going torpedo-boat capable of performing any service which is within her province. To produce the power necessary for this speed a single vertical engine possesses several advantages which recommend it for the purpose. It will require a smaller number of men to run it and keep it in order. The first cost of the single engine is very much less than that of two engines for the same power. The economy of the larger unit is superior to that of the smaller, and the single engine admits, too, of a roomier and more commodious engine-room than would be possible with a pair of engines in the same space.

Coal Capacity.—Ideas vary widely as to the necessary coal capacity which should be given to a sea-going torpedo boat. It is necessary that, when such boats are acting with a fleet, the embarrassment occasioned by the necessity of their procuring coal shall be reduced to the least possible, by giving them as large a capacity as practicable and making some of the times of requiring coal by the torpedo-boat coincide with the times at which the larger ships of the fleet must seek coal. The normal endurance of American battle-ships of least endurance is about 7000 nautical miles. It is not practicable to obtain so great a radius as this in the sea-going torpedo-boat. It is, however, possible to provide in the design of these boats for sufficient coal to steam 3500 to 4000 nautical miles at 10 knots. The sea-going torpedo-boat would then require coal with the battle-ships of least endurance and once in each interval

THE BRITISH TORPEDO-BOAT DESTROYER "SPARROWHAWK," ON HER OFFICIAL TRIAL ON THE CLYDE. SPEED, 30.56 KNOTS.

between the coaling of these ships. In connection with this matter of coal capacity, the possibility of torpedo-boats receiving coal at sea from ships should be noted. In the voyage of the British torpedo-boats No. 61 and No. 62 previously mentioned, they received coal as they required it from the store-ship *Tyne*, which accompanied them, the coaling being performed without great difficulty, even during some of the very rough weather which was encountered.

Manœuvring Qualities.—The service required of the torpedo-boat demands that it should be capable of manœuvring readily in a small space. To offset the disadvantage in this regard which is brought in by the single screw proposed, the fitting of a bow rudder in addition to the usual stern rudder, and for use in conjunction with it, is suggested. This arrangement has been in satisfactory use upon boats constructed by Normand and Schichau for some years, and has proved satisfactory and productive of considerable improvement over the manœuvring qualities of boats fitted with after rudders only. A boat embodying the features which have been enumerated would, under the customary trial conditions with a load of 25 tons, representing the equipment, stores, coal, etc., on board, displace about 120 tons.

The Harbour or Coast-Defence Torpedo-Boat.

Of the value as a means of defense, of a large number of small torpedo-boat vessels attached to, and operating from, coast stations as bases, there can be no question. They would attack ships of the enemy approaching the coast, and by their numbers and activity make anchorages on the coast absolutely untenable. Ready refuge in the shallow water of the many inlets or behind outlying islands or points of land would be always open for them.

Boats of this kind require: —

1. An efficient torpedo equipment.
2. A light gun armament.
3. The least possible draught.
4. Good speed in deep and shallow water.
5. Good manœuvring qualities.

Torpedo Equipment.—It is not probable that more than one torpedo attack will be engaged in by this class of boat in each interval during which it is absent from its temporary or permanent base. During the Japan-China war, in an attack of Japanese torpedo-boats upon vessels in the harbour of Wei-hai-wei, which resulted in the sinking of the *Ting-Yuen*, seven participating boats fired eleven torpedoes. In a later attack upon the ships in the same harbour, which resulted in the sinking of the *Lai Yuen*, the *Wai Yuen*, and the tender *Paufah*, four participating boats fired seven torpedoes. There is reason to believe that provision for two torpedo tubes for the long 18″ torpedo, with one torpedo for each tube, should be sufficient for these boats.

Gun Armament.—To provide the boat with means of embarrassing and keeping down the fire of an opponent when detached and chased by boats guarding ships which it is attacking, provision must be made for an armament which may be manned by the crews of the torpedo-tubes, and which is capable of a rapid and fairly accurate fire. The machine gun seems to be the best arm for the purpose. A battery of three of these, manned by the crews of the torpedo-tubes, should be effective.

Draught.—Boats of this class must depend to some extent for their safety upon their ability to elude chasing torpedo-boats and destroyers by running into shallow water. The draught should then be made as small as practicable. Since the change of trim occasioned by high speed in a small boat is accentuated in shallow water, it is necessary to provide for a form of stern which will reduce to a minimum this evil, and it may even be desirable to provide for some trim by the head in still water so that the maximum draught at full speed shall not be increased on account of this change of trim.

Speed.—The first two of the conditions fixing the limit of speed in the case of the sea-going torpedo boat (the necessity of being in a class by itself and the necessity for sufficient speed to

ensure success in a torpedo attack), hold in the case of the coast or harbour-defense boat. A speed of 22 knots is believed to be consistent with these two requirements.

The operations of such boats as these are necessarily restricted to night or foggy weather, and all the time not occupied in attack is spent within easy reach of coal, which can be had at every port, large and small, along the coast. There is, therefore, not the necessity for large steaming radius which exists in the case of the sea going torpedo-boat, but full speed may be expected to be more commonly employed than in the case of the sea-going boats. Coal to steam fifteen hours at full speed should provide the means of striking quickly at a point some distance from the base and returning to the base after the attack.

REAR ADMIRAL DANIEL AMMEN, U. S. N.

A Biographical Sketch.

THE Ammen ram, the *Katahdin*, of the United States Navy, is at the present time the object of perhaps more interest to naval authorities all over the world than any other modern ship of war afloat. In view of this and also because of the article on "The Ram in Modern War Fleets," which is concluded in this issue, and in which the *Katahdin* is considered in some detail, a biographical sketch of Rear Admiral Daniel Ammen, the designer of the vessel, seems particularly appropriate, and the writer has taken pleasure in responding to the invitation from the editor of CASSIER'S MAGAZINE to prepare one for its readers.

Admiral Ammen was born in Brown County, Ohio, in 1820. That part of Ohio was then but sparsely settled. The primeval forest still covered the bulk of the land, and the numerous brooks and streams, fed by perennial springs that for ages had not known the sapping power of the sun, ran with unvexed flow down the steep hills or through deep ravines into the Ohio river in all their brawling strength and freshness. The life and habits of the people in the scattered clearings and isolated hamlets were of the simple, sturdy and independent character that the land no longer knows. Neither political scandals nor abounding luxuries had yet beguiled the consciences or softened the rugged ideals of that day.

Travel was largely on horse-back, neighbourly greetings were infrequent, and school facilities were limited.

Amidst such surroundings the childhood and early youth of Ammen were passed. Among his chosen playmates was a lad some two years his junior. One winter's day the younger of the pair,—then seven years old,—fell into a freshet-swollen stream and would have perished in its cold, swift current, had it not been for the ready wit and alert movement of the elder, who, running, like a deer, down the bank of the stream, scrambled out on the trunk of an overhanging tree, just in time to reach down and snatch his companion from what would have been a watery grave had the plucky little rescuer's object failed. Little dreamed the latter then that the playmate he had saved from drowning would become, a generation later, the most famous American of his time,—the great soldier and President of the United States,—General Grant.

But quiet and uneventful as were those early days in Southern Ohio, young Ammen had heard enough of the

great world beyond to determine his choice as to his life's work; for one day, just past his fifteenth year, he astonished his father by telling him that he had made up his mind to go to sea as a midshipman in the navy, and, despite paternal discouragement, he persisted in his determination.

His elder brother, who had been graduated from the Military Academy at West Point some years before, and who was at the time an instructor at that national school, secured for him the coveted appointment, and in November, 1836, the young aspirant for national honours left home to enter upon the life he had chosen.

His story of the journey to Washington, as told in his interesting book, "The Old Navy and the New," published in 1891, gives a vivid description of the incidents and difficulties of travel in the United States at that period. It also pictures in humourous lights and shades the conditions and peculiarities of service life in those days in a manner not a whit less graphic and amusing than the scenes and drolleries of man-of-war life, depicted by the magic pens of Cooper and Marryatt in their inimitable stories of the sea.

Upon arrival at Washington, Midshipman Ammen, as we will now call him, got a leave of absence of three months, which he improved in the study of mathematics under the instruction of his brother at West Point.

At the expiration of his leave, he repaired to Norfolk, Va., and reported for duty on board the store-ship *Relief*. From that time forth, for the next five years, he was kept almost continually afloat, serving in four different vessels in cruises on the Atlantic coast, as well as in the Gulf of Mexico and the Mediterranean.

Naval cruising in that time of long passages, salt provisions, scant allowances of water, and the winds of heaven as the only motive power, was a far different matter from the deep-water service of the present period, which has steam and electricity at its command for propulsion and light, the establishment of well-defined sea itineraries and many other comforts which the old-time mariner never knew. But rough and rugged, — sometimes dangerous, — as were the conditions which Ammen was called upon to face, he took things with a philosophic patience and humourous grace which never faltered. During all this cruising he had been given but one short leave of absence to visit his home. Some of the good folk who called to see him thought it a great mercy that he had been spared to come back at all from the stormy seas, but when they heard that he would soon return to shipboard life they made up their minds that he was flying in the face of Providence in the most reckless manner.

We next find him at the naval school at the Naval Asylum, Philadelphia, preparing himself, with others of his class, for examination preliminary to promotion to the grade of passed midshipman. The school was then a crude affair, and beyond instruction in geometry, algebra and practical navigation the curriculum did not go. But after a few months the examination came off in the presence of a board of grizzled old commodores and captains, who knew much more about reefing topsails and tacking ship than of the books of Euclid or of algebraic formulæ. The result was that Ammen and his classmates were all made happy by being certified as passed midshipmen and eligible for commission as lieutenants when that day of further advancement should arrive for them. This was in 1842.

Seven years later, in the course of seniority, that coveted commission came to Ammen, and he now felt well settled in his profession. Meanwhile, never idle, he had seen service on board different ships as navigator in the Mediterranean, the East Indies and on the Coast Survey; and now, as a lieutenant, he was almost continuously on sea duty in many quarters of the globe.

The opening days of 1861 found him in charge of the naval rendezvous at Baltimore,—his first detail of shore duty,—but the opening events of the great American Civil War determined him to proceed at once to Washington. Providing himself with a horse and

equipments, he set forth in all haste. The country roads swarmed with armed men, and he was frequently obliged to change his route to avoid them. Then the horsemanship that he had acquired in boyhood, in company with his companion, "Lysse" Grant, stood him in good stead. He knew how to spare both his horse and himself from fatigue and yet get on readily.

Arrived in Washington, he was ordered to executive duty at the Navy Yard there, but in a few weeks was transferred, as executive officer, to the steam frigate *Roanoke*, which was fitting out at New York. A little later he was ordered to assume command of the gunboat *Seneca*, in which vessel, and subsequently in the double-ender *Sebago*, he took gallant and effective part in the capture of the Confederate stronghold at Port Royal, and in all other operations of Admiral Du Pont's fleet on the coasts and in the sounds of South Carolina, Georgia and Florida in 1861 and 1862.

Detached from that service in the late fall of 1862, he was ordered North to take command of the monitor *Patapsco*, then building at Wilmington, Del., having been commissioned a commander in the United States Navy during the preceding July. The monitors were a great innovation in naval construction, as well as in ordnance and engineering detail, and the ablest officers of the service were selected to command them. It is needless to add that Ammen was ranked as belonging to that distinctive class in point of merit and ability, not only by his fellows, but by the Navy Department.

On January 2, 1863, he put the *Patapsco* into commission, and six days later arrived with her in Hampton Roads, where he was kept on protective service off Newport News until January 30, when he was ordered to proceed to Port Royal in tow of the U. S. S. *Pawnee*. Bad weather overtaking them, they were compelled to put into Beaufort, N. C., and stay a few days; but on February 10 they reached Port Royal, when Ammen had the gratification of resuming duty under the gallant Du Pont. The monitors were still untried as to their real offensive powers, and the *Montauk*, *Passaic*, *Nahant*, and *Patapsco* were ordered to Ossabaw Sound to try conclusions with Fort MacAllister. After a bombardment of eight hours, candor compels the admission that the result was somewhat chilling, especially in view of the exalted estimate that men in their comfortable offices at the Navy Department held as to the powers of those vessels, both as to offence and defence.

The test at Fort MacAllister certainly did not promise the success at Charleston that had been confidently counted upon at Washington. The supreme showing was soon to come. On April 5, seven monitors, the ironclad *Keokuk* and the armoured frigate *New Ironsides*, were assembled off Charleston bar. The *Patapsco*, Ammen's vessel, and the *Catskill* went in over the bar that evening. The next day the rest of the vessels crossed and anchored in the roads preparatory to the attack, the admiral's flag flying on board the *New Ironsides*.

At noon on the 7th, the signal was made to get under way, but owing to some derangement on board the monitor *Weehawken*, the ships were not fairly in motion until a quarter after one. Of the nine ships comprising the attacking force, the *Patapsco* was fifth in line. The attack failed. The tempest of fire encountered discovered defects and weaknesses of plan and construction that showed the monitors to be neither invulnerable nor perfect in their appointments.

In a brief one hundred minutes 2209 shot, shell and rifle-bolts were hurled at the ships, while the latter were able to fire only 139 shots in reply. Five of the monitors, one of them the *Patapsco*, were disabled more or less in that short, but terrific, combat, and it became apparent that repairs to the monitors must be made and defects remedied before it would do to attempt another trial of strength with the enemy's batteries at that point.

Under such conditions Admiral Du Pont concluded to discontinue opera-

tions for the time being and withdraw. His action was much censured in some quarters at the time, but the fact stands recorded in the chronicles of historic truth that his successor in command never captured the defenses of Charleston despite all his hammering of the rebel works with the iron-clads which had been much improved in various details. In this the writer speaks from personal knowledge, for as executive officer of the *New Ironsides*, the operations at Charleston, both in Du Pont's and Dahlgren's time, were as "familiar to him as household words."

Ammen had been on duty continuously since the beginning of the Rebellion and became somewhat broken in health. The monitors were damp and confining and promotive of rheumatism. Many of the officers and men on board those vessels began to suffer from that crippling ailment, among them the *Patapsco's* commander; and as the damaged monitors were at Port Royal for repairs, with no prospect of immediate resumption of operations at Charleston, he consented to a medical survey, on the finding of which he was detached from his command and ordered North on sick leave. This was in June, but the early days of September found him back at Charleston Roads, charged with special duties. About two months later, Admiral Dahlgren held a council of war as to another attack on the enemy's defenses. The decision was adverse to such movement, and Dahlgren sent Ammen to Washington to lay before the Navy Department the condition of affairs in that quarter of operations.

He was subsequently employed on court-martial duty and as commander of the steam sloop-of-war *Shenandoah*. At this period he had the pleasure of renewing his acquaintance with General Grant, whom he had not seen in twenty-one years. The pleasure was mutual. The two met at Culpepper, in Virginia, and as they rode over the country, getting occasional glimpses of the Army of the Potomac encamped along the River Rapidan waiting to begin its last campaign, we doubt not they became boys again. A few days after this pleasing episode, Ammen received an order to take charge of a draft of 220 seamen on board the Panama steamer *Ocean Queen* at New York, bound for Aspinwall. Hardly had the ship got to sea when signs of insubordination on the part of the draft became evident. The second day out the ringleaders grappled with the captain of the ship and the chief engineer with intent to overpower them and take charge of the vessel. At this juncture Ammen, who had prepared for such emergency, gave the order to fire, and discharged his own revolver at the mutineers. Two of them fell dead. The rest, after a few decisive words from Ammen, gave three cheers and retired to their quarters, and the trouble was ended.

Ammen had always been distinguished in the service for his tact in the handling of men and his happy methods of discipline, but his manner had been so quiet on this occasion that the mutineers had made a grand mistake as to his quality and temperament. Upon arrival home he made a full report of the affair to the Navy Department and asked for a court-martial. After a long delay, very vexatious to him, he was brought to trial and honourably acquitted.

Some weeks later, Ammen was ordered to the steam sloop *Mohican*, fitting out at New York. In that vessel he took able part in the attacks on Fort Fisher and its capture. After the fall of Fort Fisher, the *Mohican* was ordered to Port Royal for duty in Dahlgren's fleet. A little later Sherman's march in the rear of Charleston caused the evacuation of that hitherto defiant stronghold. The *Mohican*, now condemned for repairs, was ordered North, and about the middle of May Ammen put her out of commission at Boston.

So closed his war service; but, five months later, he was ordered to command the just finished double-turretted monitor *Miantonomoh*, at that day the most formidable vessel afloat under any flag. Holding that command about seven months, he was relieved at his own request. Then he entered upon

important shore duties, which continued until October, 1867, when, having been advanced to post rank about fifteen months before, he assumed command of the flag-ship *Piscataqua*, bound to the Asiatic station.

Meanwhile, his old association with General Grant had been further renewed in a manner most agreeable to both, and among the first things the General did upon his election to the presidency of the United States was to make a request of the Navy Department to have his old friend ordered home from the Orient.

When Ammen reached Washington, as the result of such request, he was appointed chief of the Bureau of Yards and Docks of the Navy Department. A year later, the more important and congenial duties of the Bureau of Navigation were placed in his hands. As chief of that bureau, and standing in closer relation to the Secretary of the Navy than any other officer, he had at last the opportunity of carrying out his long-cherished plans and purposes. For many years he had earnestly advocated the construction of a ship-canal to connect the Atlantic with the Pacific. The conduct of surveys for such purpose was now put into his hands, and all the Isthmian expeditions in Grant's administration were organised under his personal direction. He also reorganised the Hydrographic Office and put it upon a basis of systematic endeavour and progressive usefulness that it had not known before. Nor may we forget that among other good fruits of his administration was the determining of the longitude of places by telegraph, the improvement of day and night signalling at sea and the revolutionising in the United States service of deep-sea soundings in methods and accuracy.

The accurate ascertainment of the depths of the sea was a problem that in all ages had baffled the efforts of seamen, and it was not until Sir William Thomson, now Lord Kelvin, of Glasgow University, brought forward his simple dynamometric machine for sounding with piano wire, first tried by him in the Bay of Biscay, in 1872, that the ready and easy solution of the problem was demonstrated.

The *Challenger*, already engaged in her notable world-round expedition, declined the use of the machine, and the United States Coast Survey also discouraged its adoption; but Ammen, himself an inventor and skilled hydrographer, holding broad views with regard to the testing of new appliances for sea use, at once ordered the *Tuscarora* to be supplied with one of these machines. The machine was still in an experimental state, but modifications and improvements were readily made on board ship, and the results accomplished in its use were so happy and indisputable in character, that no one would now think of using any other appliance for sounding the depths, for all the machines of the day are but modifications of Lord Kelvin's apparatus. The writer was the commanding officer of the *Tuscarora* at that time, and his official and personal correspondence with the Commodore,—for he now held that rank,—at that period snows how earnest were the efforts of that ever-busy and active-minded officer in the promotion of new methods for the good of the service and the nation.

When the Isthmian surveying parties had got fairly to work, the president of the United States designated the chief of army engineers, the superintendent of the Coast Survey and the chief of the Bureau of Navigation,—Ammen,—as a board to consider all matters pertaining to the surveys, and, after exhaustive examination and careful consideration of all the data secured, to render full reports. This board had the canal matter under advisement four years, and then reported unanimously in favour of the Nicaraguan route.

Meanwhile, Commodore Ammen had written, and has continued to write, many able arguments,—given to the public in varied forms,—in demonstration of the superiority of the Nicaragua line over the Panama and other routes examined. Such tireless efforts, indeed, have caused him to be known in some quarters as "the father of the Nicaragua canal."

In December, 1877, he was promoted to Rear Admiral. Six months later he resigned from the bureau which he had so ably administered, and, under the forty -years' clause of the statutes, voluntarily went upon the retired list. But he had no idea of passing the rest of his life in idleness. On the contrary, his activity in varied directions for the public good relaxed never a whit.

Under the auspices of M. de Lesseps, an international congress to consider the American Isthmian Canal question met at Paris in May, 1879, and Admiral Ammen and Civil Engineer Menocal were appointed by the President as the delegates of the United States. The fresh survey which is now being made of the Nicaragua line will, it is believed, reaffirm the superiority of the Nicaragua route, as well as present an estimate of less cost, owing to the recent marked improvements in methods of excavation.

The marine ram *Katahdin*, which was recently commissioned for war service, is, as previously noted, the conception of the Admiral. About twenty-seven years ago, he began to make calculations of weights, and study lines of naval construction and displacement most favourable to speed, facility of turning and immunity from the shot of an enemy, but it required the effort of ten years before he could get favourable action from official sources. Then the Naval Advisory Board recommended the building of five vessels of his type, of 2000 tons displacement. Still, about fourteen years elapsed before Congress voted the money to build even one.

The *Katahdin* has not developed the speed expected, but the Admiral claims that such outcome is due to the alteration of his lines to suit the views of the Bureau of Construction of the United States Navy Department. Be that as it may, the Admiral encountered much opposition from several directions in his desire to have his ideas given thorough practical test. but we may not doubt the ram will give a good account of herself if ever engaged in battle, and demonstrate the value and effectiveness of such a type of vessel for war purposes.

The balsa, or life-saving raft, adopted by the United States Navy Department, and placed on board American ships about thirty years ago, was also devised by Admiral Ammen. Always of observant turn, he had noted in the days of his lieutenancy the rafts made of the wood of the balsa tree,—a wood very light and porous in fibre —used for water transportation and surf battling purposes by the people of Peru; and it occurred to him to build long, cigar-shaped casks or cylinders, which, connected in pairs by suitable frames and partial planking, would afford a stable platform that would be very useful in cases of shipwreck or in landing through surf. For such utilisation of Peruvian method, he was given a diploma and voted a silver medal by the Massachusetts Humane Society.

It is jocularly said that every sailor when he gives up the sea longs to buy a farm. The Admiral certainly gave point to such saying. for no sooner had he settled down to bureau life in Washington than he bought a farm of several hundred acres, beautifully watered by never-failing streams, twelve miles from the city, on the line of the Baltimore and Ohio Railroad. There he built a new house, where for many years he has dispensed a most generous, but unostentatious, hospitality, which has been enjoyed from time to time by many distinguished men.

He also indulged in his love of outdoor work in the cultivation of the vine, the planting of orchards, the making of wine and cider, and other congenial pursuits of the field and farm. Nor did he neglect the paths of literature, for during the past forty years he has been a frequent contributor to various publications, and his autobiographic story of "The Old Navy and the New" is one of the most entertaining books of real naval life ever written. His volume of the Atlantic Coast, descriptive of naval operations during the American Civil War, is also a valuable contribution to war literature.

His intimacy with General Grant con-

tinued until the latter's death. During the years of the General's presidency the unwritten law, rarely broken, was that Ammen should take his Sunday dinner at the Executive Mansion at Washington, and we may well believe that their table talk, reminiscent, anecdotal and political at such times, was of the most interesting character; for it is said that the generally silent Grant was a delightful talker when with his close friends, and the Admiral has always been known as a charming and instructive conversationalist, bubbling over with wit and humour and inimitable drolleries.

The Admiral, now a widower, has been twice married. Two sons and three daughters have been born to him. The oldest son, Ulysses Grant, is an assistant paymaster in the United States Navy; the second son, Du Pont, is a graduate of Lehigh University, and holds a clerical position in the United States War Department. His daughters are all still with him at the homestead, which bears the name of Ammendale, and which, owing to his energetic action, has the convenience of a post-office and country store near by; while perhaps half a mile away, the fine buildings of the college and chapel of the Christian Brothers, standing on a gentle hill, amidst extensive and beautiful grounds, make a striking and attractive feature in the landscape. The grounds of the institution were the gift of the Admiral to the fraternity. Such benefaction in the interest of education and the Church will forever link his name and public spirit to and with that beautiful region of Maryland.

GEORGE E. BELKNAP,
Rear Admiral U. S. N., Retired.

Current Topics.

THE recent performances of the United States battle-ship *Oregon* and the gunboat *Marietta* in steaming from high up along the North American Pacific coast around Cape Horn to the West Indies have very properly challenged the admiration of the whole world. Until quite recently much more had been heard of the failings of warships than of their good points, and one was almost tempted to believe that the average modern naval vessel was so delicately constructed and so complex a piece of machinery as to be scarcely fitted to withstand in due measure the rough usages of war, or the knocking about of a protracted sea voyage under the pressure of high speed and with all kinds of weather. When, several years ago, the United States cruiser *Columbia* crossed over from Southampton to Sandy Hook, at the entrance to New York Harbour, in a little less than seven days, racing successfully against one of the crack Atlantic liners, her performance stood unparalleled in naval history. It bordered, in fact, on what had for long been considered the impossible. What the *Oregon* and the *Marietta* have done, however, is a worthy counterpart of that earlier magnificent performance, and admirably demonstrates what may be accomplished by good engineering, even when subject to the exacting conditions of naval restrictions.

WITH the miscellaneous collection of torpedo vessels which to-day are to be found in different navies, comprising torpedo-gunboats, torpedo-cruisers and torpedo boat destroyers, of various armaments and speeds and now of probably doubtful utility for the particular purpose held in view when their types were originally proposed, it is interesting to note the conclusions arrived at by Lieutenant R. C. Smith, of the United States Navy, in the course of a very comprehensive discussion of torpedo-boat policy submitted some time ago to the United States Naval Institute in the shape of a prize essay. Briefly, Lieutenant Smith maintains that torpedoes are not permissible afloat except in large ships, submerged, or behind armour, and in special torpedo-craft of less than 300 tons displacement. There are only two types of torpedo-boats that seem to meet the requirements of torpedo service with a squadron at sea, and, from fixed bases, for the defence of seaports and harbours. The first is a high-sea torpedo-boat of 250 to 300 tons, generally similar to the present British de-

stroyers, to mount three long 18-inch torpedo-tubes on the central fore-and-aft line, with a spare torpedo for each tube, and a homogeneous battery of eight 3-pounders, preferably of the automatic type; this boat to keep the sea with the fleet at all times and to be used either as torpedo-boat or destroyer. The speed and coal endurance are to be as high as the displacement and armament of the boat will permit.

THE second type is a first-class torpedo-boat of 150 feet and 120 tons, carrying two or three torpedo-tubes, all for the long 18-inch torpedo, and mounted on the central fore-and-aft line. In case two tubes are carried there will be a spare torpedo for each tube; if three tubes, then one torpedo only for each tube. The gun armament is to be four 3-pounders. A speed of 24 knots will be ample for this boat, and will permit of a coal endurance of at least 18 hours at full speed. Both types should have twin screws and the engines should be in separate compartments longitudinally to minimise the risk of complete disablement, and to permit coal protection throughout the machinery space. The proportion of the two types of torpedo-boats could very well be one of the larger to two of the smaller, and that number would be a suitable proportion to each battle-ship and armoured cruiser. In fact, it would be wise policy to provide for a destroyer and two torpedo-boats whenever a large ship is laid down.

EITHER non-inflammable wood or an efficient substitute for it is badly wanted by all the navies of the world. In spite of the fact that there are, at present, in existence at least nine or ten processes for rendering wood non-combustible, none of them have been adopted by the British Admiralty, though all have been subjected to careful and repeated trials. The United States naval authorities tried one kind of non-inflammable wood on the armoured cruiser *Brooklyn* some time ago, but have since replaced it with ordinary wood. The German naval authorities, who are profoundly convinced of the necessity of using non-inflammable wood in the construction of their warships, have made numerous experiments in this direction during the past four years without any tangible results. While the theoretical need of a non-inflammable flooring for warships has long been felt, the matter did not become a sternly practical one until one of the Chinese battle-ships was set on fire by a shell from a Japanese cruiser in the battle of Yalu. This lesson has recently been further emphasised by the burning of the Spanish cruiser *Reina Christina* from shells discharged by Admiral Dewey's fleet at the battle of Manila. It seems quite settled, therefore, that ordinary wood in a warship is a source of danger in time of battle. That the hint given by the Yalu fight has not been neglected, at least by the British Navy, may be inferred from the armament of the *Majestic* and other battle-ships of her class, which consists of four twelve-inch and twelve six-inch quick-firing rifles, besides twenty smaller guns. The obvious purpose in dropping from the twelve-inch to the six-inch gun, without using the intermediate eight-inch, is to gain the advantage of the quick-firing mechanism, not applicable to any larger size than the six-inch, in order to pour continuous rounds of shot and shell into the unarmoured surfaces of the opponent's battle-ships. Indeed, Sir George Sydenham Clarke, one of the most eminent British authorities, goes so far as to predict that in the next war in which Great Britain has a part the main reliance of her warships will not be in armour-piercing projectiles, but in the demoralising and slaughtering effect of common shell on the enemy's crew. This plan of action presupposes wood to make destructive splinters, and, on occasions, to go on fire.

IT is abundantly evident, in view of what has just been said, that an efficient

non-inflammable wood, or in its absence, a suitable non-combustible substitute, would be eagerly grasped at by all the leading naval powers of the world. It was at one time thought that wood might be largely dispensed with in the construction of warships, and this theory was partially carried out in the building of H. M. S. *Devastation* as it is to-day as far as practicable in the various kinds of torpedo vessels. But the verdict of sailors has been unanimous that war vessels without a considerable quantity of interior sheathing of wood or some similar non-conducting substance are always freezing cold in winter and unbearably hot in summer. Besides, as in the case of the *Devastation*, the unsheathed gratings and other metal surfaces under foot soon wore so smooth as to become slippery—a contingency not lightly to be contemplated in the hurly-burly of a naval battle. Wood was, therefore retained as the least evil open to choice. Why none of the well-known varieties of non inflammable wood was adopted is a harder question to answer. It is now fifty-three years since Payne's process was discovered. This consisted in inclosing the wood to be treated in a close iron vessel, exhausting the air, and allowing a solution of sulphate of iron to flow in. This at once thoroughly permeated the pores of the wood, after which a solution of muriate of lime was added. A double transference of these chemical compounds followed, making sulphate of lime, or gypsum, and muriate of iron. In effect, the final result of the process was to fill the pores of the wood with gypsum, thus rendering it completely incombustible. Some years later, Burness used his famous chloride of zinc in making wood non-inflammable, but the process never came into general use. The British Admiralty at one time had great hopes of reaching the desired end by immersing wood in tungstate of soda, but the process was found to be too expensive and also to increase unduly the weight of the wood so treated. It is more than probable that the increase in weight militated against the adoption of Payne's process. Prof. Pepper found, after a series of careful experiments, that phosphate of ammonium gave the best result in making wood non-inflammable. The British Admiralty, about a year ago, experimented inconclusively with the Fox process, of the nature of which no data are at hand.

THERE is some reason to believe that in addition to increasing seriously the specific gravity of the wood made non-inflammable—an insuperable obstacle in the case of warships, where every pound of possible displacement above the minimum is required for guns and armour—most of the processes take the life out of the wood, or, in other words, make it so friable that it offers too little resistance to ordinary wear and tear. The attention of some inventors has, therefore, been turned to substitutes for wood. It is easy to reckon up the ideal qualifications for such a material. It must be non-combustible; it must be a good non-conductor of heat, and must have toughness, lightness and endurance under foot. If we should assume, by way of illustration, that a substance could be discovered which would have the cohesiveness of cement not subjected to shearing or tensile stress, and, like cement, could be spread with a trowel; that it had the hardness of compressed paper pulp, such as is used for car-wheel centres; that it had the lightness of corn pith; and that it had the toughness and non-resonance of wood—then we should have the ideal substance for warship floorings and wainscottings. That such a substance may yet be discovered is not beyond the bounds of possibility. Already approaches have been made to it by mixtures of sawdust, magnesite and chloride of zinc, in which the latter is the binder. If in this product the quantity of magnesite could be indefinitely diminished and the quantity of sawdust indefinitely increased, the problem would be one step nearer solution. We have reserved to the last one of the most indispensable qualifications in

a non-inflammable substitute for wood. Naval authorities are sure to be swayed in their choice of a new material by the test of its not splintering under shell fire. This at once adds to the problem the invention of a substance which will be hard enough to wear under foot and soft enough not to splinter. Yet modern asphalted streets have a hard skin on a softer foundation, so that even this difficulty may be overcome.

To what extent restriction in the use of wood on German war vessels has been carried, has recently been told by Herr Dietrich, the constructor-in-chief of the German Navy. In the outfit and construction of new German ships wood is used only for a few minor points. Wooden deck planks are no longer laid; steel deck plating is covered with linoleum, sometimes over a layer of cork. In the crews' quarters the sides of the ships are not ceiled; in the officers' rooms the ceiling is made of steel plates, lined with cork. For cabin bulkheads the steel is covered with thin woollen cloth, and with cork lining underneath where it is desirable to exclude sound or lower the temperature. Where heat is radiated from engine or funnel casings, cork lining also is used. All wood is removed from the ammunition rooms, save the racks for shells and powder charges. These are still made of wood. For all ladders and steps steel is used. The handrails on the conning bridges are no longer of wood, but of some other material which will not burn or splinter, and which is more agreeable to the touch of the hand than steel or brass. Chart-houses and captains' rooms on bridges are made entirely of steel and fitted out with non-combustible materials. Since all such changes will be a little exaggerated, it seemed to be advisable to abandon wood for the interior fittings, and especially for the furniture, and to resort to fireproof material which will not splinter. Many things were tried; furniture was made of steel and aluminium, lined with cork and covered with linoleum or canvas; but it was not equal to wood furniture. Only the bedsteads are constructed of iron, steel or brass. The insignificant quantity of wood in the few pieces of furniture when ignited is not considered a dangerous source of smoke, but rather it is the outfit of the state-rooms, the mattresses, blankets, clothing and books.

One argument that has been made in favour of building a comparatively large number of small warships rather than a smaller number of large vessels, with large crews, is that the smaller ones afford the greater number of independent commands and opportunities of training for command. Between 1872 and 1883 seventy-six sea-going fighting ships were launched for the British Navy, varying in displacement between 430 and 2000 tons, and the number of men and officers in these ships ranged from 59 in the smallest to 220 in the largest. These ships were to be found all over the world. Admirals, captains, and leading officers of to-day were all trained in them, and splendidly trained. These ships, however, have been displaced during recent years by larger vessels, with larger crews, making, for each command, larger claims on naval estimates and on the reserve of men. Some of the foremost authorities now lean to the opinion that too much trust is placed in big ships and guns, and too little in the skill, enterprise and valour which may be had in the direction and management of a ship of moderate size. To multiply such smaller ships is to multiply the chances of getting good men in command. Piling up armour and guns condemns many such men to subordination to their inferiors.

Triple-screw ships are becoming the fashion. There is already a goodly array of them in different navies and every promise of more to come in spite of the fact that, from a purely economic point of view, they have not accredited

themselves as well as was expected. Professor Carl Busley, of the German Navy, for example, pointed out some time ago, before the Verein Deutscher Ingenieure, in discussing the results of trials of the German triple-screw cruiser *Kaiserin-Augusta*, that the maximum performance with three screws was 21.65 knots and 13,900 I. H. P., the slip of the middle screw being 10.49 and of the side screws, 13.8 per cent. With the centre screw removed, the I. H. P. was 8822 and the speed, 19.3 knots; the slip rose to 18.3 per cent. With the centre screw replaced and then uncoupled, the speed, with almost exactly the same I. H. P., a difference of only 1 H. P., was only 18.8 knots, or ½ knot less. The slip was 19.4 per cent. After the two side screws had been removed and with only the centre engine working, a speed of 15.2 knots was obtained with 3948 I. H. P., the slip having now reached 28.4 per cent. The side screws having been replaced and then uncoupled, the speed was 14.6 knots with practically the same I. H. P., while the slip reached 32.5 per cent. When using the centre screw alone, the coal per hour was 5201 pounds, and with the two screws only, it was 5075 pounds. The loss, due to the resistance of the two uncoupled wing screws, was thus shown to be greater than the advantage gained by the use of the centre engine with full pressure over two equally large engines working at half pressure only. For economy's sake it would, therefore, be better to steam such cruisers with two engines, instead of with only one, as is done for practical reasons.

CONSIDERING all this, therefore, there must be weighty reasons to justify the continued building of triple-screw vessels. This is, in fact, the case, and these reasons, from the navigating, engineering and construction points of view, have been given by Professor Busley as follows:—The military or navigating reasons are that, as the blades of twin screws usually project far beyond the hull, these vessels cannot comfortably lie alongside of a dock or go through narrow dock gates, as the blades may easily strike against the walls. Besides, with these projecting screws, there is the danger that during an engagement, as, for instance, a mishap in ramming or running past too closely, a propelling blade may be broken off. The centre propeller of a triple screw vessel is, however, so well protected that it is not exposed to any danger of damage. Experience has furthermore taught that twin screw vessels, when one of the engines or propellers has been disabled by an accident, can attain only three-quarters of their former greatest speed with the remaining engine, although the same full boiler power is available. But if a triple-screw vessel loses one propeller, nearly nine tenths of the greatest obtainable speed with three screws can still be maintained with the remaining two screws. Besides, the triple-screw vessel will have greater handiness and manœuvring capabilities on account of the more favourable location of the rudder behind the centre screw, an advantage of great importance in these days of fast steaming. In addition, a triple-screw vessel, steaming with one engine, needs only one-ninth of its total engineer force to run it in three watches. Should such a cruiser suddenly be required to go into action, two-thirds of the engineer force, perfectly fresh and rested, would be available. This is a factor which cannot be too highly estimated, for the speed and manœuvring of the cruiser depend on it to a large degree.

THE engineering reasons for the use of three screws may be summed up as follows:—The extreme practicable limit for the size of one engine may be placed at about 15,000 I. H. P. This engine, to run easily at the necessary high piston speed, must have a very long stroke. But, a vertical engine of this description will be so high that it will project far above the protective deck and make protection impracticable. Three smaller engines, each of 5000 I. H. P., which

can easily be installed under the protective deck on account of their short but adequate stroke, are besides preferable, because they do not require such large casings and forgings as the single powerful engine. The requisite soundness of these parts, and, therefore also, their strength and durability, can certainly be more readily detected for the three small engines, and they can on this account be put in with greater assurance.

FINALLY, the advantages in construction follow from the fact that fast ships must have very fine lines aft, so that the water may follow to the propellers with the least resistance. The engines can be installed better in the sharp after body of triple-screw vessels than in similar twin-screw vessels, for there is still ample room for the third engine in the narrow space abaft the other two engines. The whole machinery is moved further aft and the shafts may be made shorter. In bad weather, the shafts are, therefore, subject to less bending action than the long ones of twin-screw engines. They need not, therefore, be made so strong, and a saving of weight results. Finally, in the narrow vessels, the engine keelsons, to which the bed plates are secured, are closer together. The bed plates need not, therefore, be so strong, although offering the same resistance, and a further reduction in weight is effected.

IN reviewing the various sources of trouble to ship owners the London *Engineer* counts among them steel upper decks, which, when not sheathed with wood, waste away rapidly through oxidation. The sea spray falling upon either an iron or a steel deck must necessarily be highly corrosive by reason of the salt it contains in solution But the steel deck wastes much more rapidly than the iron one, and so it is now very usual for upper decks, when unsheathed, to be of iron. It is to be regretted, says *The Engineer*, that such should be found necessary, for the iron of today is by no means an ideal material, and it must be much thicker, and therefore heavier, than a steel deck so as to be of equal efficiency. An anti-corrosive coating for steel weather decks is sadly needed, and any inventor producing one which will stand the wear and tear of foot traffic, as well as of loading and discharging, and at the same time be proof against the variations of temperature in summer and winter, would speedily acquire a fortune. At present shipbuilders are, unfortunately, often driven to use iron for the upper member of the girder in ship construction when every other consideration but durability would point to the use of steel.

THE destruction recently of another so-called "fireproof" business structure in New York City affords an additional illustration of the practical impossibility, under the present conditions, of checking a fire when it attacks the upper floors of a modern American "sky scraper." Since business buildings in the United States have towered to a height of over six stories the difficulty of providing adequate fire protection has become almost insuperable. Chief Bonner, of the New York City Fire Department, than whom there is probably no higher authority in these matters, does not scruple to declare that none of the modern "sky scrapers" are fireproof, and that once a fire gets a good start in one of the upper stories nothing can be done but to let it burn. He holds that it is utterly impossible to fight a fire above a distance of 125 feet. The only remedy that is suggested is the adoption of interior fire plants and the organisation of a fire corps of employees to operate them in case of an outbreak. A number of the high modern buildings in New York are already supplied with interior stand-pipes and the necessary equipments, but the majority of the owners of such structures are content to depend upon the so-called fireproof construction of the walls and floors, a protection which time and

again has been proved fallacious in actual experience. The insurance companies are actively working in this matter, however, and it is not unlikely that pressure will be placed on the building department of New York to compel owners of buildings over six stories high, in that city, to provide their own fire-fighting apparatus. It is not merely a question of danger to the building itself and its occupants, but also to the lower buildings adjoining, and to those across the street, when the street is narrow, as is so often the case in the crowded parts of a city. This was proved in the case of a recent fire, when two buildings on either side of a high structure were burnt out and those opposite were damaged and saved only with difficulty from sharing a similar fate.

METAL sheathing for railroad passenger cars has been used experimentally in several instances in the United States for somewhat over a year past, and the results, according to latest accounts, seem to have been of a satisfactory character. At a recent meeting of the Master Car Builders' Association, for example, a passenger car on the New York, New Haven and Hartford Railroad was described, the exterior of which was finished with sheet copper instead of the usual finish of paint and varnish. No paint or varnish was used on the outside of the car body excepting on the roof, platforms, hoods and window sash. This car was put in service in January, 1897, between New York and Boston, and after a year's operation the car is said to have quite as good an appearance as when it first left the shop. A coach on the same road is reported to have recently been covered with aluminium bronze and a third with sheet aluminium. The aluminium bronze finish will weigh practically the same as the copper, while the weight of the aluminium will be about one third that of the copper finish. It is expected, however, that the aluminium covered car will cost more than would a similar car newly painted and varnished, but the difference in cost will be quite small.

THE new method consists of covering each piece of wood sheathing, paneling, letter board, and other parts with the sheet metal before applying the parts to the car, so that the metal tightly fits the wooden pieces. The sheathing is plated by means of a simple arrangement of rolls. Each piece of sheathing and its corresponding piece of metal is passed through the machine together and comes out ready for use, the metal fitting the tongue and extending into the groove at the sides. The sheathing is applied to the car in the usual manner, the grooved side being driven over the tongue and nailed so that the fastenings do not appear on the surface. The metal surface is not punctured in any place by the fastenings, and all joints are water tight. The numbers and letters on such cars are made of cast brass or aluminium, as desired.

As previously stated, the first car turned out was covered with copper, and the cost of this car was about $50 more than it would have been had paint and varnish been used; but this cost was considerably increased because the process was new and the work was done slowly. It is stated that it requires from 800 to 900 pounds of copper to finish an ordinary passenger car, and that the first cost of metal plating cars need not exceed the cost of painting. A saving can be made by using a less expensive grade of lumber with the metal finish than can be used under paint and varnish, and also with the new process the cars are less time in the shop. Where it requires 28 days to finish a coach under the usual system, the same work can be done by means of the metal plating in 18 days. There is an additional feature of the new system, in that it is not necessary to shift cars from one shop to another, all the work being done in one place, thus saving the cost of moving in the shops.

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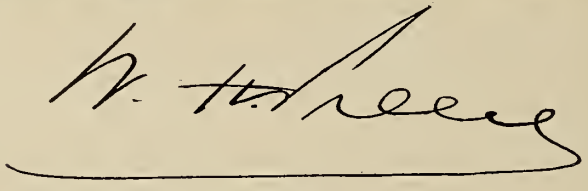

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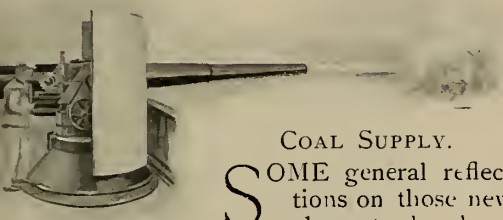
CASSIER'S MAGAZINE.

VOL. XIV. AUGUST, 1898 No. 4

COAL SUPPLY, SPEED, GUNS AND TORPEDOES IN MODERN NAVAL WAR.

By Vice-Admiral P. H. Colomb, R. N.



COAL SUPPLY.

SOME general reflections on those new elements that have entered into naval war, so far as their use and value have been illustrated in the war now existing between Spain and the United States, may be of interest to the readers of this magazine.

Coal supply and speed are, of course, the two elements that differentiate sail propulsion from steam propulsion. We get speed and certainty for voyages made under steam, and the full advantages are reaped in peace time, because the coal supply can be exactly arranged for and calculated according to the work required of it, for that can be known. But for the warships in war, no such special arrangements and calculations are possible. Coal supply can be treated only generally before war breaks out, and no one can say beforehand whether it has been justly and economically allotted. The difficulty of coal supply becomes the *per contra* in war of the certainty and the speed which the steam voyage ordinarily exhibits.

An extraordinary advance in the destructive power of guns has followed in the wake of that burst of inventive passion which steam awoke and continually arouses. What are the general effects of such a change, and what is the *per contra* there?

Then comes the entirely new weapon, the torpedo, of which we have little more than an experimental experience, but which may be destined to force the gun into second place; or may itself be beaten back; yet shows no sign of remaining a placid spectator of the triumphs of its rival.

With regard to coal supply we may mark the tremendous change by considering for a moment the last war, the war of 1812, that was carried on across the Atlantic. In the present war the American naval force may be taken to have been, nominally, as three to two of that of the Spaniards. In the war of 1812 the odds against the United States were, perhaps, fifty to one, as compared with Great Britain. Yet the United States fought and won many frigate actions on their own side of the water, and had cruisers attacking British commerce and capturing British warships in many parts of the world, even on Great Britain's own shores.

Now we see that steam war is localised. The superior American Navy makes no attempt to carry the war into

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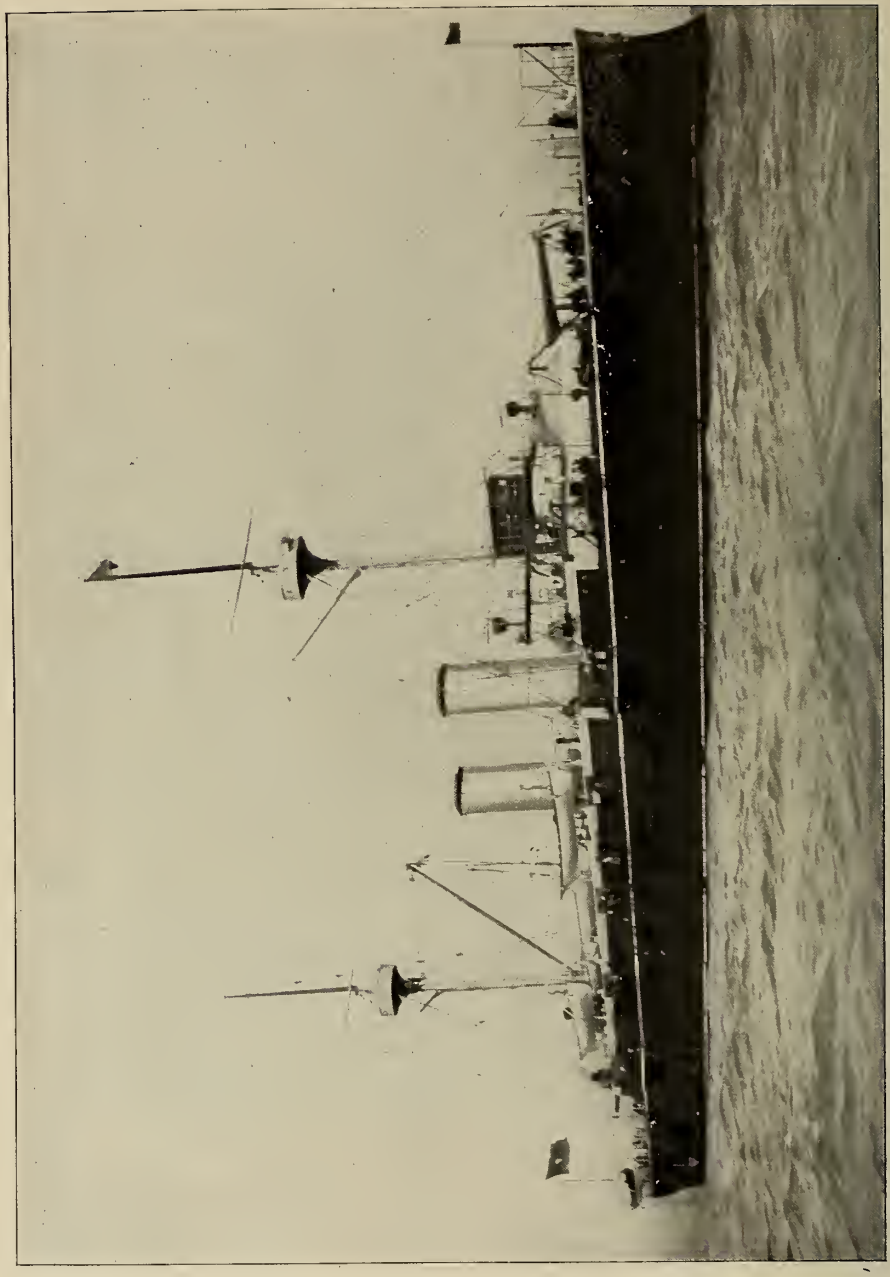

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THE SPANISH ARMOURED CRUISER "VIZCAYA," DESTROYED IN BATTLE WITH THE UNITED STATES FLEET OFF SANTIAGO, ON JULY 3, 1898.

European waters, as Great Britain in 1812-'14 carried it into American waters; it is incapable of watching European Spanish ports, and Spanish ships are as free to come and go out of them as if there were no war. The Spaniards, on their side, have resigned themselves to such defensive war as is offered by land batteries, and by sorties, few and far between, from blockaded ports.

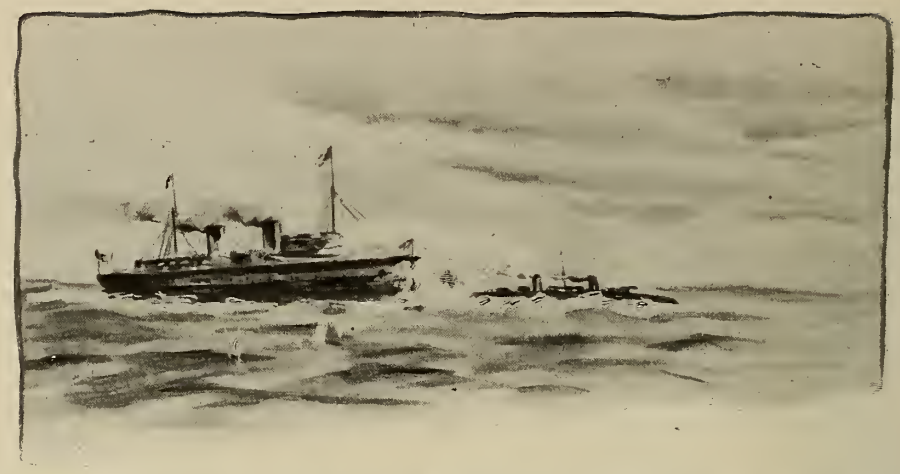
We cannot wholly explain this difference by reference to nationality. It is perfectly true that the capture of Cuba, and not the general reduction of Spanish power, is the object in view of the Americans; and it may be frankly assumed that there is not in the Spanish race that enterprise and energy which is to be found all over the States; but I think few will deny that, in such a war as we now witness, had it been conducted under sail, there would not have been such complete collapse of naval power on one side and triumph on the other. We must remember that this is the third war, wholly or chiefly conducted under steam, where this characteristic has appeared. Things were so in the Crimean War, and in the Franco-German War, and now in this one. Surely, when we remember that it was never shown in any sailing war, we can only say that it is steam propulsion and coal supply that governs.

No doubt a great proportion of the American ships are quite capable of steaming across the Atlantic; and it may be supposed that a strict blockade of Cadiz, such as that port has known so well in former days, would have had more effect in convincing Spain of the hopelessness of resisting than any other measure that could have been adopted.

AN INCIDENT IN THE BATTLE OFF SANTIAGO BETWEEN THE UNITED STATES AND SPANISH FLEETS.

There would have been no difficulty in setting it up in sailing days, for a ship starting from the Chesapeake would have come away with three months' water on board and a larger supply of most other necessaries. She could, perhaps, in arriving off Cadiz, have fixed herself there for two months certainly, and in any case she would have found a never-ending water supply only a few days' sail distant in the streams of Letnan.

But now the American ships, arriving on the Spanish coast, could not begin the blockade of Cadiz until they had



THE U. S. AUXILIARY CRUISER "ST. PAUL," BEATING OFF AN ATTACK OF THE SPANISH TORPEDO BOAT DESTROYER "TERROR," AT SANTIAGO.

filled up with coal; and that coal must either have preceded them, or have been brought over with them in colliers. These, however, would have been of no use, unless smooth water, uncovered by any batteries, and not too far from Cadiz, could have been found. Such colliers would, in any case, be open to the enemy's attack, and whether at sea or at anchor, would require the protection of warships. It is not to be said that such difficulties as these are insuperable. On the contrary, if America cannot draw from Spain the conditions of peace which she may demand, and the war goes on after Cuba and Porto Rico have fallen, she will be compelled to set up war in European waters. But the point is, that coal supply offers such a hindrance to operations that were everyday matters in sailing war that they are postponed till necessity compels their adoption.

Although, therefore, I have no certain information on the point, I think we may take it that the American ships off Cienfuegos, and, later, off Santiago de Cuba, have found smooth water anchorages, the nearest possible to the ports they have been watching, and have from time to time taken in coal from colliers at anchor there. In acting thus with regard to coal, they are doing only what always has been done with regard to other stores since naval war took its regular form. All our blockading squadrons in the days of sailing wars were accustomed to use smooth water anchorages, either in or outside of the enemy's waters for the store ships to lie so that the warships might be replenished without moving farther than necessary from their blockading stations. In the mixed steam and sailing war of 1854-'56, the practice was continued, both for coals and stores, as a matter of course.

After all, however, it is a fact that for the fleet that is strong enough to take the offensive, only hydrographical conditions need affect the coal supply of the ships which are blockading or watching the enemy in his ports. And though, for instance, in the present war, the United States, very much because of coal supply, has not yet set up a watch upon the war or commercial ports of Spain, if it goes on, we must reasonably expect to see United States ships coaling in Cadiz bay and capturing Minorca as a coaling station for the ships that are watching or blockading the Spanish Mediterranean ports.

Hence the *per contra* of coal supply for the dominant fleet is not serious. It drops its established "naval bases" just as Schley has dropped Hampton Roads, and Sampson, Key West; or

as Great Britain dropped Gibraltar, Malta, and the home ports in the Russian war, as the Federals dropped their ports in the American Civil War, and as the French dropped Cherbourg and Brest in 1870. It is to be observed that in none of these cases do fortifications or garrisons come at all into view. The fleet itself is its own defence, whether it is at sea, on its station, or coaling and storing at its temporary depot.

If we take coal supply for the defensive fleet, as illustrated by this war, we see simply that as soon as it is located in its own ports the question of its coal supply is not raised, because the expectation of having to meet an equal or a superior force when it puts to sea makes its exit useless. It, therefore, remains where alone it is, for the time, secure, namely, in port. This is, without doubt, the general case, which may be varied, should there be hope of evading the fleet that is watching off the port, or should the inside fleet, from circumstances, find itself temporarily superior to the fleet that is watching it.

Here, of course, if the blocked-up fleet is short of coal and there is no coal to be had, it loses its opportunities on a question of coal supply. Still this is no new thing in naval war. It was sometimes difficult to supply the wants of the French fleets in Brest in the matter of stores and provisions, except by sea; and when British cruisers stopped the coasting trade into Brest, it stopped, in the process, the probable exit of the war fleet. And then it becomes clear that if the port in which the blocked steam fleet lies is not coal producing,

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THE U. S. CRUISER "MARBLEHEAD" IN CUBAN WATERS.

BOMBARDMENT OF THE SPANISH SHORE BATTERIES, AT SANTIAGO, BY THE UNITED STATES FLEET.

and the coalless fleet finds no coal-store there, it is effectually put and kept out of action for so long as the watching fleet may be able to prevent the ingress of colliers. The offensive fleet need keep no considerable force on the watch.

But in war, there may be a longer or shorter time within which the fleets, even of the inferior naval power, are moving at sea, and it is here, more than in any other case, that the question of coal supply comes in to hamper the inferior fleet, and to make it more inferior than its nominal force would ever have allowed it to be when fleets operated under sail. The proceedings of Admiral Cervera's four first-class cruisers and three destroyers offered a most useful illustration of the conditions, and of the difference existing between the coal supply of the superior and of the inferior fleet. At the same time, I am bound to say that the conduct of Cervera's squadron is not explicable but upon extraordinary mismanagement or incapacity.

It will be remembered that the squadron left the neutral port of St. Vincent on April 29; was next heard of at Martinique on May 12; was reported to have touched at the Dutch island of Curacoa, and to have left on the 15th; then on the morning of the 19th it passed into Santiago de Cuba, and was almost at once blockaded there.

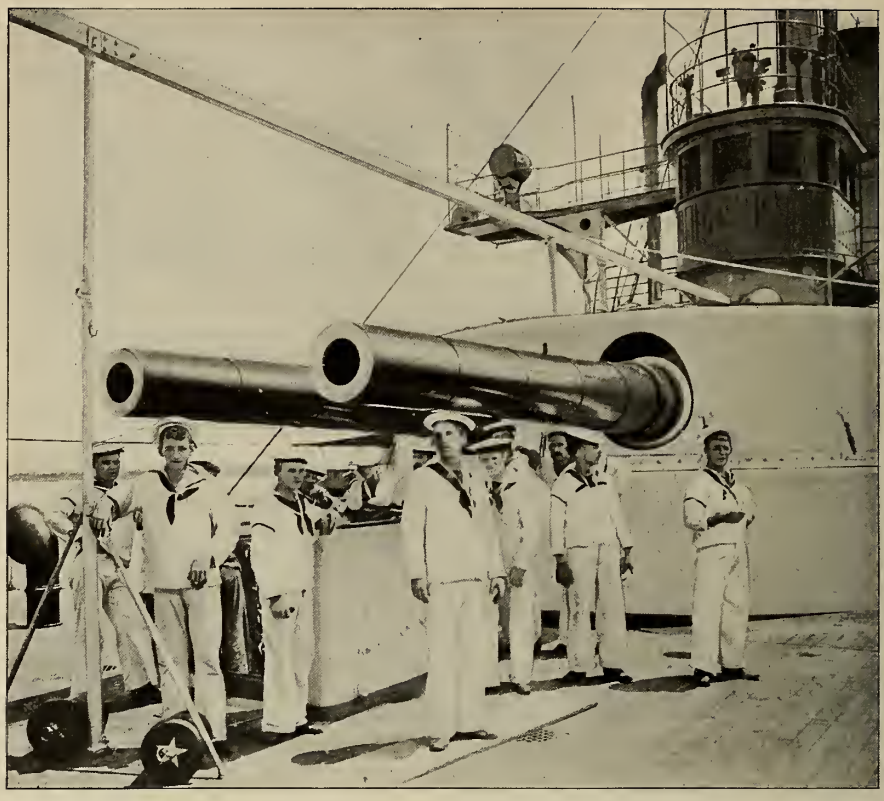
It is not easy to suppose that this was all originally intended. Except under councils of the most fatuous character, no advantage could possibly have been imagined from the passage of a really fine squadron from the port of St. Vincent, where it was safe, to that of Santiago, where the best fate that could be hoped for it was that it should ultimately be destroyed to prevent its falling into the enemy's hands. There must, I think, have been an intention to do something offensive against the Americans, at least before the shelter of a Cuban port was sought. There certainly were some openings at a date, about May 15, when, according to reasonable calculations, Cervera might have struck one or two blows.

At that time, Sampson, with the heavier ships of the American fleet, was to the eastward, off the north coast of Porto Rico; there were two or three lighter cruisers on the south coast of Cuba, watching Cienfuegos, and there might have been odd cruisers around the western end of the island, and such squadron as there could have been off Havana it was not beyond the power of Cervera's squadron to deal with. In any case, it was probably certain that some warships, colliers, store ships, transports, and what not were to be found at Key West, which might have been destroyed by an enterprising commander of such a force as Cervera nominally possessed.

Of course, the moment Cervera was known to have passed into a Cuban port there was an end of his opportunities, just as there was when, in 1796, the combined Franco-Spanish fleet located itself in Toulon instead of striking at the greatly inferior fleet of Servis; or when, in 1799, the great Franco-Spanish fleet of ninety sail located itself at Ferrol and was watched and masked there by concentration of the British forces; or when Villeneuve sought the shelter of Cadiz instead of striking the blow that was open to him at the fleet of Cornwallis off Brest.

Cervera, steaming past Martinique, might have steered straight for Santiago, might have sent a destroyer in for intelligence, and might have gone on to strike his blows as indicated. Why did he let his whereabouts be known at Martinique, when he might have run past at night, and nobody the wiser? Why did he again show himself at Curacoa? And why did he pass into Santiago without attempting anything? Of course, there may have been broken-down and disorganised engine rooms. It is to be feared that Spanish genius is little mechanical. The only plain reason we can adduce for what took place is the question of coal supply. And even here we are met by difficulties.

Cervera's three 7000-ton cruisers were reported to be able to stow 1200 tons of coal,—by no means an excessive capacity, when our *Australia*, of 5600



ON THE U. S. MONITOR "AMPHITRITE."

tons, is supposed to carry 900 tons of coal, and our *Amphion*, of 4300 tons, carries 1000 tons. The fourth cruiser, the *Cristobal Colon*, of 6840 tons, is said to carry 1000 tons, proportionately somewhat less. Our *Australia* was officially given a coal endurance of 8400 miles at 10 knots, and the *Amphion* 11,000 miles at the same speed. Our own *Edgar*, of 7350 tons, is stated to require no more than 1000 I. H. P. to drive her 10 knots, and that, at 3 pounds per I. H. P. per hour and a coal supply of 850 tons, would give her a coal endurance of not less than 6000 miles. Assuming the same horse-power and coal expenditure for the sake of margin, and so as not to go into details that would be out of place in an article of this kind, the three larger Spanish cruisers should have had a coal endurance of 8800 miles, and the *Cristobal Colon* of 7400 miles.

Of course, we all know that few, if any, ships can show in practice their theoretical coal endurance, but here we have taken considerable margins, and yet we shall note that if we suppose Cervera's ships went into Santiago short of coal, the margins are not approached. St. Vincent to Martinique is 2200 miles; thence to Curacoa is 470 miles, and from Curacoa to Santiago is 625 miles; a total of only 3295 miles, which distance, supposing the speed was 10 knots, should have left the larger cruisers with 4500 miles in their bunkers, and the smaller ones with 4100 miles. But the ships did not steam 10 knots or anything like it. They took 19 or 20 days to steam 3300 miles, or, not counting stoppages, at the rate of 7.2 or 6.8 knots. Leaving St. Vincent on April 29, and touching at Martinique on May 12, gave a speed of not much more than 6½ knots; and leaving

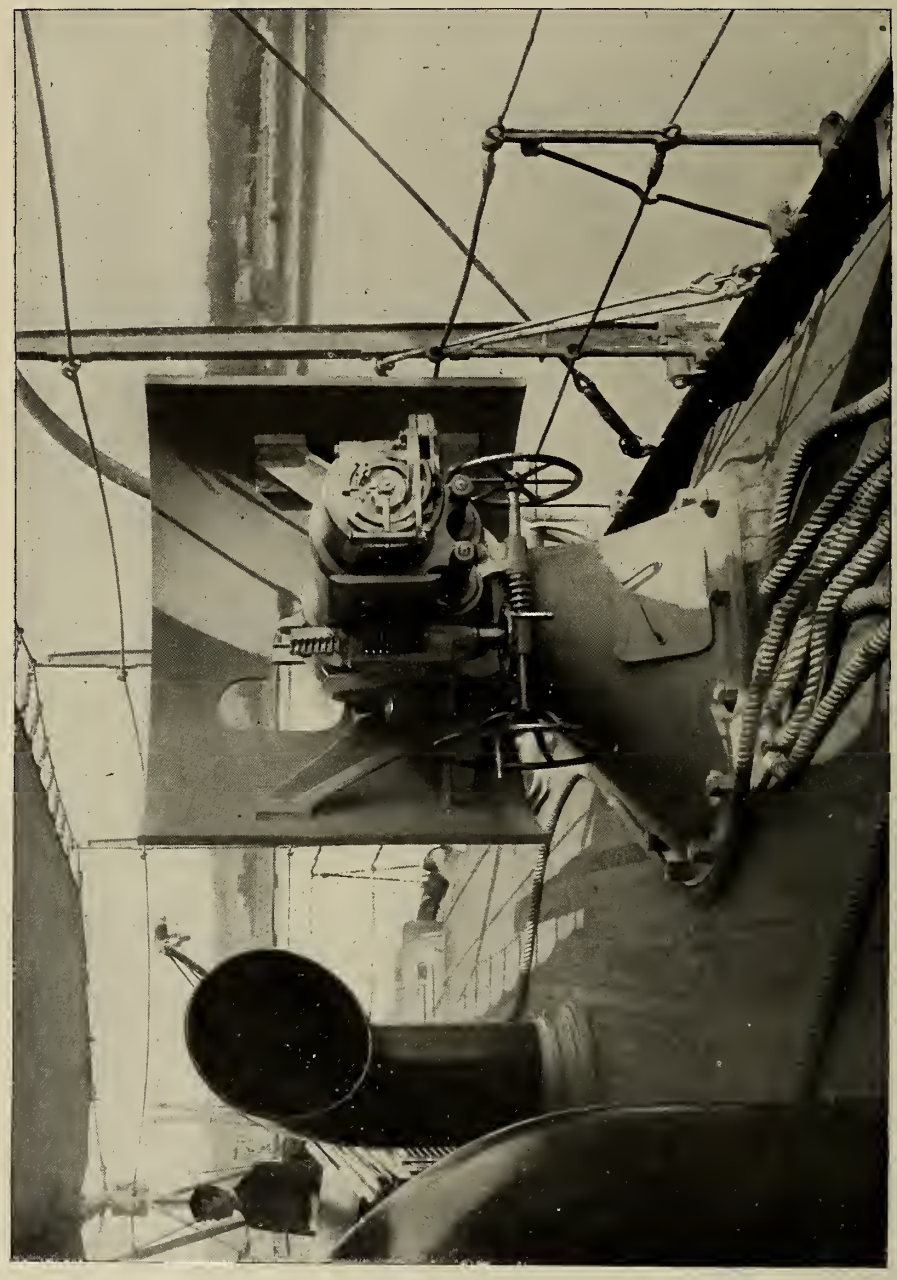
Curacoa on the afternoon of the 15th and arriving at Santiago on the morning of the 19th, gave a speed across of less than 6 knots.

We have to think, however, of the three destroyers that accompanied the squadron. These vessels are generally credited with 4000 miles coal endurance, and if there had been an attempt to steam them across the Atlantic, and they had all arrived with Cervera at Santiago, they must have been short of coal when they got there. But it would have been an obvious device to have saved their coal by causing the three largest cruisers to tow them across the Atlantic, and it is not easy to say that this duty would have put the larger cruisers below the *Cristobal Colon* in the matter of coal endurance.

I am thus brought to the conclusion that Cervera's proceedings could only have been governed by questions of coal supply if he left St. Vincent short of coal, a proceeding which any British admiral would have stigmatised as a mad one. Though the reports had it that Cervera's ships coaled at St. Vincent, there were some who suggested that there was some difficulty about supply. If there was, we can only say that there was either poverty, or incapacity, or mismanagement, or all three together.

A reflection and a suggestion which I put forward twenty years ago, and which has never failed to present itself to me as a true one, has been revived by the experience of the present war. It is that as all classes of ships are always liable to be associated in the same duty in war, there is no good reason for varying the coal endurance of the different classes. Some standard of mileage should be adopted, the highest that is practical at a given speed, say, 8000

A 4-INCH RAPID-FIRER IN THE UNITED STATES NAVY.



A REAR VIEW OF ONE OF THE 4-INCH RIFLES ON THE U. S. GUNBOAT "HELENA."

miles at 10 knots, allowance being made for differences of auxiliary expenditure.

Doubtless there are practical difficulties because of the variations in proportionate horse-powers required to drive ships of varying displacements. But, in my opinion, coal endurance should give way to gun power in the larger ships, and gun power should give way to coal endurance in the smaller ones, so that all the ships in any squadron should act on equality on any service in which a state of war may demand. At present, as I have gone to some trouble to point out, there is no general rule, so that we have force giving way to coal endurance in one case, and coal endurance giving way to force in the next, there being a general tendency exactly the opposite of that which obtained in the days of sailing ships, namely, that locomotion generally should give way to force in the smaller ships, and that force should give way to locomotion in the larger ones.

Though we have no accounts of it, I cannot doubt that Admiral Sampson must have felt over and over again the inconvenience of a varied coal endurance in the ships under his command. Of course, I am referring chiefly to ships which are of the same general characteristics. I do not know that we can deal in these respects with a single rule applicable alike to 14,000-ton battle-ships, to unprotected cruisers and to torpedo vessels pure and simple. But even here, I think we might probably reach more uniformity than we do.

Speed.

In the course of this war there has been hardly anything to illustrate the relative value of speed compared with other elements of force. As there has been no sea-battle, its tactical value has not been tried at all; and in the only two cases where its strategical value might have been illustrated the speed which we must consider possible has not been used.

These two cases are the voyage of Cervera across the Atlantic and the voyage of Schley from Key West to block the Spanish admiral in Santiago. The natural strategy of Cervera's squadron was to strike its blow at the earliest possible moment, on the natural supposition that on the news of its quitting St. Vincent Sampson would have concentrated his main forces and would have left lighter squadrons on blockading service exposed,—which he did; and that Schley's squadron would have been detained in the North,—which it was,—because of the fear that Cervera's course might be directed thither. I have shown, however, that from whatever cause the omission arose, there was no attempt to use speed which was presumably possible.

With regard to Schley's voyage from Key West to Santiago, pure strategy would have prompted the highest possible speed, because the idea was that Cervera had some project in view which required for its success an early exit from port before an equal or superior force could get into touch with him there. But other matters came in the way. In the first place, from Key West to Santiago round the east end of Cuba, is 750 miles, while round by the west end of Cuba the distance is 950 miles. As Schley went round by the longest way, the question of the value of speed hardly arises. But in any case, Schley was only off Cienfuegos, less than 600 miles from Key West, on the evening of June 24, so that it is difficult to suppose that there was any attempt to act at speed.

Schley may have used speed to pass originally from Charleston to Key West, but there is no note of it, and, on the whole, it seems safer to say that on the American side the strategical value of speed was never put to the test. It is certainly one of the disappointments of actual war that the dramatic surprises, the hairbreadth chances and escapes of imagined war come so rarely. War generally follows commonplace rules that experience has shown to have been always in operation and that steam seems hardly to have interfered with at all.

Guns.

As far as the fighting in this war has gone, it has been almost wholly a ques-

tion of gun fire, and chiefly between ships and batteries. It has long been a commonly received axiom that in modern wars, as indeed it was in former wars, the encounters between ships and batteries would be few and far between. The Americans themselves laid this down almost in terms on a review of the conditions and results of the British bombardment of the ports and batteries at Alexandria. At the first blush it would seem that this axiom had been

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QUICK-FIRING GUNS IN ACTION.

upset for good by the experiences of the first few weeks of the war, for we heard of nothing but bombardments by the American ships, and there seemed, according to the accounts, to be no places left in Cuba that had not been bombarded.

I think we should pause before coming to a conclusion on this head. What was in the minds of the naval officers who wrote on the case of Alexandria was serious bombardment with the design of immediate conquest, or as a preliminary to a different form of attack which should result in conquest. There, again, the axiom was based on the well-ascertained fact that the fire from a given gun, mounted on land, was very much more accurate than the fire of the same gun, equally well served, afloat.

I had myself added to this the reflection that the cost of mounting a given gun afloat was so enormously greater than the cost of mounting the same gun on land that even if their accuracy was equal, it would be a losing game to pit the one against the other. It will not be possible, I think, to disestablish these two propositions. Then, again, the bombardments implied in the axiom were serious bombardments, not even punitive like that of Alexandria, but such as were to be persevered in for a definite and destructive end.

Evidently the axiom does not relate to cases which are mere reconnoissances, mere drawing of the fire of batteries in order to ascertain their situation and strength, or even for the minor purposes of putting heart into the sea-

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THE U. S. AUXILIARY CRUISER "YANKEE."

men gunners and ensuring them practice. If we were to take the first accounts of the exchanges of fire between the American ships and the Spanish batteries that came by cable across the Atlantic, every bombardment was "terrific," serious, and continuous, and left everything in ruins behind it. But as successive installments of news came in, the operation distinctly dwindled until we knew that, at best, there had been but a distant exchange of projectiles of a somewhat desultory character, and without a more definite object than reconnoissance.

But even of this, I think there has been more than most of us expected, and I doubt if most of us are quite clear as to the advantages which the Americans have derived, or have supposed they derived, from the practice. The early claim of both sides has almost invariably been that their projectiles had done enormous damage to the other side. But repudiation of damage has always come from both sides a little later.

We have every reason to suppose that the damage done by the ships to the batteries would not be heavy, and if any ships had been seriously damaged their withdrawal for repair would have made denial useless. The more sober telegrams have usually allowed that no great damage had been done to the Spanish batteries, and it seems quite certain that the only American vessel seriously damaged by Spanish artillery was the torpedo-boat *Wilmot* at Cardenas. There is no doubt that she was badly mauled, suffering some loss in killed and wounded, and requiring to be sent back to Key West for repairs.

The axiom presupposed guns of equal power, equally well served, ashore and afloat. If, on the first exchanges of fire, as at Havana, the Americans found that the guns mounted were of inferior power to their own, or were worse served, the projectiles falling short or passing wide, it seems almost natural that the ships should amuse themselves, and alarm and disturb the enemy by an occasional distant cannonade, which was remarkably one-sided. I think, in fact, that this explains the somewhat unexpected phenomenon.

"Battle-ships," says the able Lieutenant-Commander Wainwright, of the United States Navy, in the June number of this magazine, and his remark applies equally to cruisers, "are not designed to attack land defences, but to meet other vessels on the sea; and while they may, at times, successfully bombard fortifications, they will do so

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THE SPANISH ARMOURED CRUISER "INFANTA MARIA TERESA," DESTROYED NEAR SANTIAGO WITH OTHERS OF THE SPANISH FLEET, BY THE UNITED STATES SQUADRON ON JULY 3, 1898.

only under exceptional circumstances, and will need land forces to succeed in extensive operations."

This is a statement that will be very generally accepted, and I do not think it is at all shaken by anything that has lately taken place.

But near Manila, at Cavité, we have the gun exhibited as a power which would lead us to suppose that the Americans have damaged the Cuban and Porto Rican fortifications more than the Spaniards admit. Here we had Admiral Dewey's squadron engaging a group of Spanish ships, nominally protected by the fire of batteries at very long range, said to be 4000 yards, and practically annihilating them in a very short time.

We must admit that the nominal gun power of the American ships was greatly in excess of that on board the Spaniards, but the point is that such rapid destruction was done at such long range, and that such batteries as there were should have made such a very poor show. If the Americans could readily destroy ships at 4000 yards they could nearly as readily destroy batteries at the same range; and they would do both with impunity if the ships or batteries were armed with weapons of less range than their own, or if the shooting was worse than their own.

Then we come to some very simple but firm conclusions on the illustrations that gun fire has afforded us during this war. It is not safe to stand still with guns of a certain energy when guns of higher energy, without material increase of weight, are in existence. If we reflect in this way, we shall see, perhaps, that the increased energy that the Vickers-Maxim guns offer is a much more important and far-reaching war element than we might be disposed to think it at the first glance.

For ships the change is still more pronounced, for if report speaks truly, a given supply of ammunition for these quick-firing guns of increased energy occupies only half the space and half the displacement that a like supply would require for the ordinary guns of less energy. The advantages, no doubt, have seemed plain enough to the Admiralty, or they would not have accepted the guns; but nothing that I know of could have marked the necessity of a speedy rearmament on these principles than the fight, or rather the destruction, at Cavité.

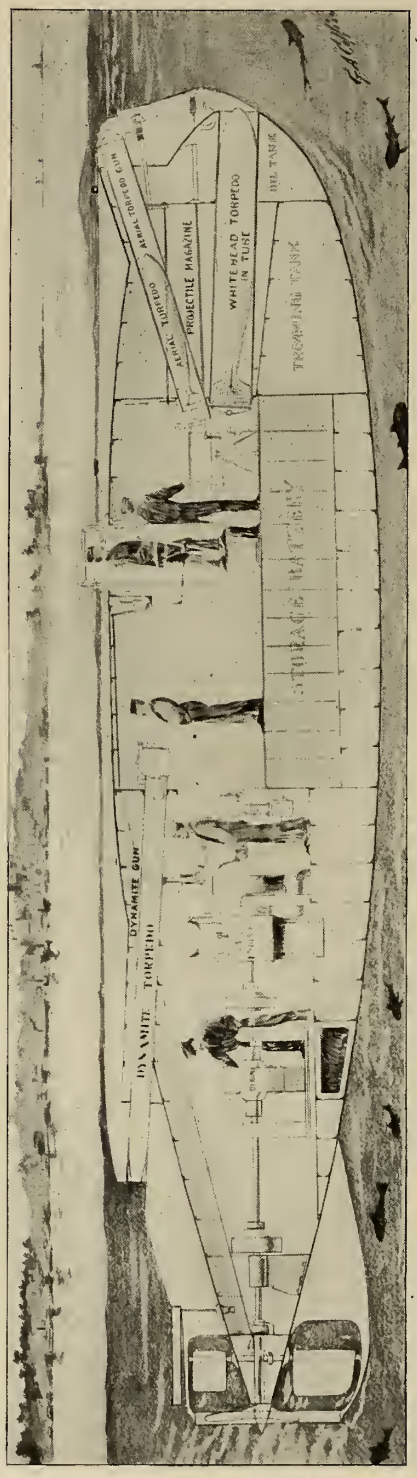
The advocates of extensive and increasing fortification by the power whose business, if she is to live, must be attack and not defence, are very fond of declaring that ships grow obsolete and fortifications do not. The actual substance, or even the form, of fortifications may not, but if I am at all right in the views I have here expressed, this would seem to be a dangerous fallacy. Fortifications, to be of any use, must be up to date, and at least their armament must keep abreast with every change that is introduced afloat.

We all admit that it is the man behind the gun who makes the gun. We do not know, we shall not know, until we learn the actual armament of the Spanish batteries, how much of the Spanish failure to damage the American ships must fall to the share of the man behind the gun. But at least we can be sure that equal armament in ships does not represent equal force, unless there is equal skill and courage in the guns' crews. And also, that if the guns' crews in batteries do not receive as great and as careful training as the guns' crews afloat, the experience of Cavité might be repeated though the very latest patterns of guns were mounted on the platforms.

Torpedoes.

The war cannot be said to have advanced our practical knowledge of the place of the torpedo in either defence or attack. As Spain started with a superiority in the vessels forming the latest developments of torpedo warfare, —the destroyers,—it was thought probable that we should have seen her direct her attention to the employment of the one thing in which she was superior.

When the war broke out she possessed seven destroyers and four torpedo-boats. Doubtless some of them



A LONGITUDINAL SECTION OF THE HOLLAND SUBMARINE BOAT.

were not fit for sea at first, but at least there were three destroyers and three torpedo-boats at St. Vincent that might have been hurried out to Cuban waters at all hazards. The torpedo-boats seem, however, to have gone to the Canaries. The three destroyers sailed with Cervera on April 29, but on arrival at Martinique one of them had broken down, and another of them seems to have been detached to St. Pierre, in the northern part of Martinique, probably for coal.

It became doubtful, therefore, when Cervera passed into Santiago whether he had more than one destroyer with him; at the most he had but two, and the third from Martinique sought the shelter of a port in Porto Rico The remaining destroyers were left in and about Cadiz, occasionally cruising in the Straits of Gibraltar, with the view, it was supposed, of intercepting some American yachts.

On the other hand, America had no destroyers, and only seven torpedo-boats ready when the war broke out; but these were on the spot at Key West. Three or four more torpedo-boats may be assumed to have since joined the American fleet.

Since there have been practically no encounters between ships at sea there has been no opportunity of using torpedoes. But there has been full opportunity for employing torpedo-boats in the way that the British Navy at least has assumed they would certainly be employed; and if Cervera's one or two destroyers have been efficient, he has had the opportunity of employing them, not, indeed, in the way that prompted their design, but in a way it was anticipated they could, and would, be employed.

The theory of the torpedo-boat has been, first, that it should be defensive; attached to ports; and pass out by night to attack and drive away the blockading ships that, to be efficient blockaders, must be close in. And, secondly, that it should be offensive, passing even into the narrowest of the enemy's ports at night to destroy his ships within them. This latter use

has taken the fullest hold of the imagination of British naval officers, and the idea of it is causing a very great expenditure in the construction of harbours for warships to shelter in that can be effectively closed against the entry of torpedo-boats or vessels.

The theory of the destroyer is thus correctly stated by Lieutenant-Commander Wainwright, in the June number of this magazine:—"The modern destroyer is a very wonderful weapon and admirably suited to the purposes for which it was designed,—the destruction of torpedo-boats,—but it must have its limitations, as have other warlike instruments."

As originally designed, however, it was more of a torpedo vessel and less, perhaps, of a very swift light gun-vessel than it afterwards became. It was designed for the special duty of watching the enemy's ports and preventing the exit of his torpedo-boats, chiefly by the power which it possessed of chasing and overtaking these boats at sea. But as a swift torpedo vessel, even if the torpedo was in her less prominent as a weapon than in the torpedo gunboat, it was always understood that from blockaded ports she would be used just as torpedo-boats proper were used, to attack by night and drive off the blockading ships.

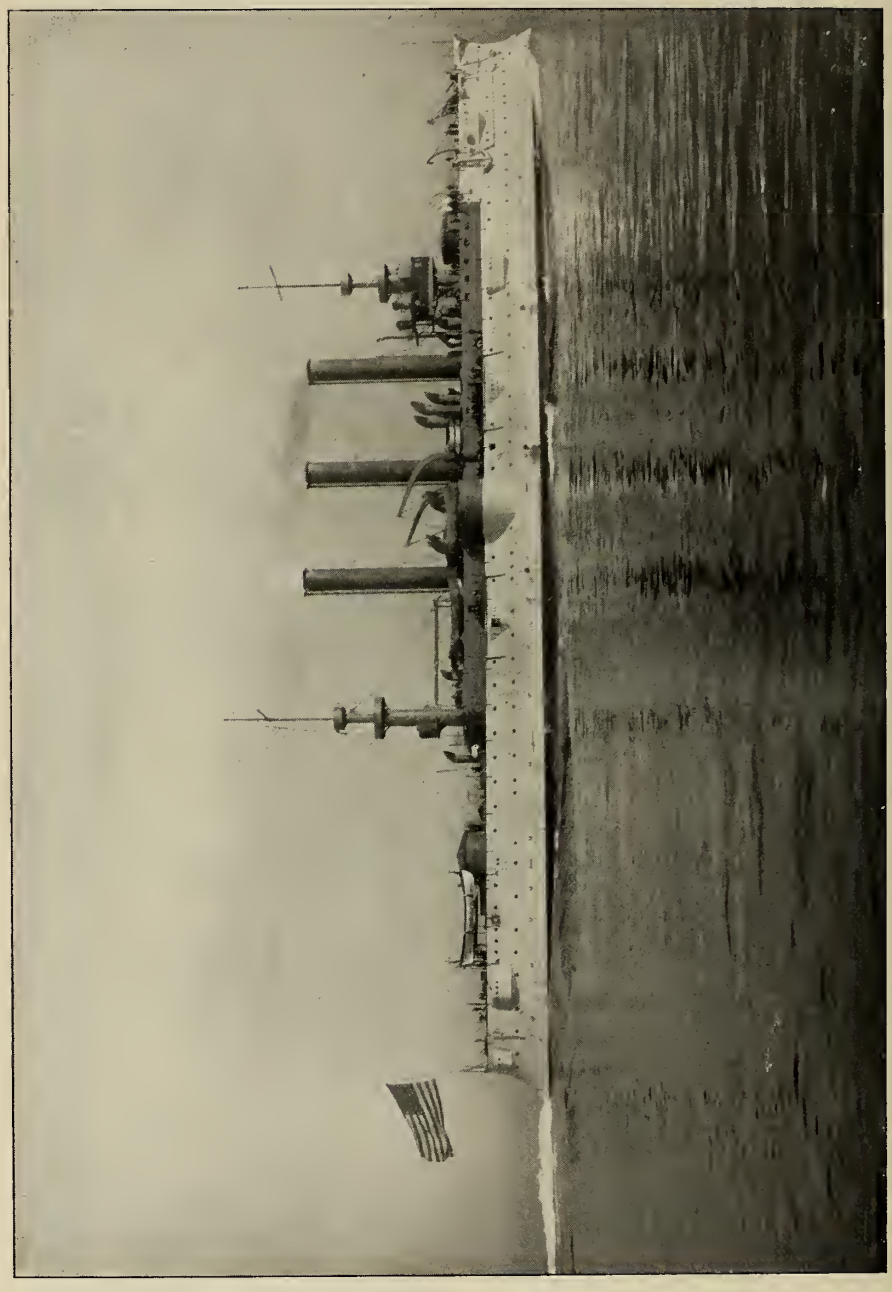
On general grounds, and on one special ground, that the danger of destroying neutrals in an enemy's harbour would restrict the indiscriminate use of torpedo-boats in the way assumed, I have never been disposed to admit more than a very exceptional use of the torpedo-boat in this way; and certainly nothing has occurred in the present war to alter my opinions.

There have been no attacks of the character predicted. The port of Havana, always known to contain some warships, has not been entered by any of the American torpedo-boats. The entry of Cervera's squadron into Santiago seemed almost specially to offer an opportunity for employing the torpedo-boats as proposed. But the torpedo-boats do not seem to have been brought round to Santiago, and instead of endeavouring to keep the entry to the port free for such attacks, the Americans specially blocked the channel by the sinking of the collier *Merrimac*.

I think it is not at all improbable that the abstention of the Americans from attacks of this kind was based on the very simple consideration that it is far more valuable and important to effect the capture of a warship than to compass her destruction.

A BOW VIEW.

Indeed, the torpedo and the torpedo-boat on the American side have both been conspicuous by their absence in Cuban waters. The Spaniards, with their two destroyers in Santiago, and probably five or six picket boats and launches all fitted as torpedo-boats, have put in an appearance on only a single night against Admiral Sampson's blockading squadron, and then there was no attempt to push the attack



THE UNITED STATES TWIN SCREW ARMOURED CRUISER "BROOKLYN," COMMODORE SCHLEY'S FLAGSHIP AT THE BATTLE OF SANTIAGO, JULY 3, 1898.

home. Indeed, if it be the case that only two torpedo craft,—whatever they were,—came out, the operation was doomed to failure.

It is putting altogether too high a value on the torpedo-boat to assume that it can perform miracles. Weapons costing perhaps not £100,000 and employing probably 100 men, can hardly be expected to prevail against weapons costing many millions and employing perhaps 5000 men. The claim for the torpedo and the torpedo vessel is no more than that, given a certain sum of money and a given number of men, it will represent a much greater force when put into the torpedo business than if put into the gun business. But no one claims that a torpedo force costing £500 and employing ten men, is the equivalent of a gun force costing £100,000 and employing 200 men.

In this, perhaps, my exceedingly complimentary critic in the June number of this magazine has not dwelt with full force on the arguments which led me to foresee a rapidly approaching change in naval opinion regarding the places of the torpedo vessel and the battle-ship. Though unquestionably it does appear to me that in purely naval warfare there is more to be got out of the torpedo than out of the gun for a given expenditure of men and money, I have really argued more on the probable trend of opinion than on any of the practical results of experimental war; so that, as we stand, I suppose that the small use which has been made of the torpedo in this war is likely to check any flow of opinion which has been setting away from the gun and towards the torpedo. It is inevitable, I think, that it should be so, although logically the course of the war has not touched the question.

There appeared to be at Manila very plucky attempt by two torpedo vessels,—I suspect mere launches,—to change the fortune of the day by boldly attacking three of the American cruisers in broad daylight. The report said that they were beaten off with very heavy loss; but I should like to know more of the circumstances of the case, and the names of the Spanish officers who commanded the boats. Apparently they deserve much higher praise than they received. Their failure, on all reasonable grounds, was a foregone conclusion, and they must have known it better than any one when they made the attempt. They ought, therefore,

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THE UNITED STATES AUXILIARY CRUISER "PRAIRIE."

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A DECK VIEW ON THE UNITED STATES CRUISER "ATLANTA."

to be all the more honoured for making it. The only account of the employment of a torpedo-boat is that given of the *Winslow* at Cardenas on May 11. She is represented to have taken part with the light cruisers *Wilmington* and *Hudson* in an attack upon two Spanish gunboats alongside the wharf at Cardenas, and the accounts make her take part as a gun vessel on equal terms with the cruisers, and not as a torpedo-boat. I find a difficulty in understanding why, or how, the Spanish batteries and the gunboats should have specially concentrated their fire upon her so well as to have disabled her, when the fire had so little effect upon her consorts, if the vessels were in an allied group of three, all at the same distance from the enemy's ships and works. Also it is not easy to understand why, with her very fragile hull and her necessarily insignificant gun fire, she should have been so brought into action

I am more disposed to believe that she was taken into action as a torpedo-boat; that there was the design of torpedoing the Spanish vessels, and that the gallant Ensign Bagley, who fell under conditions that have caused his countrymen and naval officers all the world over to honour his memory, was in advance and rushing in to fire his torpedo when the disablement of the vessel compelled retreat. If this was so, it is only another instance of demanding a miraculous exhibition of force at the hands of a vessel which would have probably been ready to do anything in reason.

HEAVY ORDNANCE FOR COAST DEFENCE IN THE UNITED STATES.

By Captain W. H. Jaques.

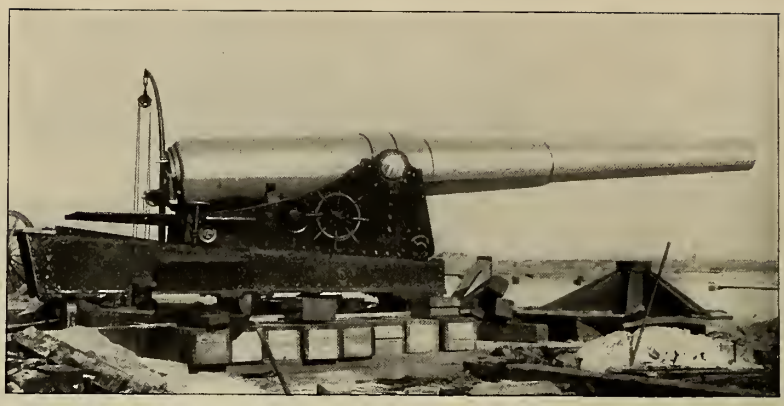
IN 1896 the United States Senate Committee on Coast Defences submitted a report again emphasising the necessity of providing suitable defence for the rapidly increasing numbers and wealth of the country's population. Very few of the words of this report are new. Every one knows that economic and prudential considerations all favour the construction of coast defences; that the cost of permanent coast defences would be about the same as that for fire insurance and police protection for one year in the twenty-seven principal American seaports where, it has been estimated, the aggregate value of the destructible property cannot be less than ten thousand millions of dollars. It is known also that the cost of the public buildings alone at these twenty-seven ports has far exceeded the amount now required to properly fortify them.

The committee referred to stated that the contrast between the cost of preparation and the cost of war itself was so manifest that it constituted one of the principal considerations that actuated its report. How more has this been proved than by the estimate that four hundred millions of dollars have already been obligated toward the cost of the present war of the United States with a bankrupt and unprepared nation; and this without considering the sacrifice of human life and the fact that the assets of the cost of war are as negative as the assets of preparation are positive. Infinitely more important than the economical question are the prevention of the sacrifice of human life and the moral effect of forefending war, which suitable preparations for war afford even if they cannot guarantee.

Again are we experiencing the full knowledge, so well expressed by a military authority in 1896, that "the American people have always been willing to expend the most extravagant sums of money after war has begun, but they begrudge the relatively small amounts which, when wisely spent in advance, would either prevent war or greatly reduce its cost. While it is true that we have never been beaten, yet our wars have, in every instance, cost us vastly more in life and treasure than was necessary, and the expense of future wars will make those that are past seem insignificant by comparison."

If we should stop to define the scope of coast defences and the tactics which should be followed to make the best use of its material, we would find ourselves in the midst of a treatise requiring many serial articles for their presentation.

General Abbot has construed the true policy for coast defence to be to fortify the chief ports along the coasts, so as not only to protect the adjacent cities and arsenals against insult, but also to provide safe refuges for the coastwise marine, and safe naval bases with coaling stations, depots of supply and places of refuge for ships of war when threatened by superior forces on the ocean, whence they may issue to act offensively as circumstances permit.

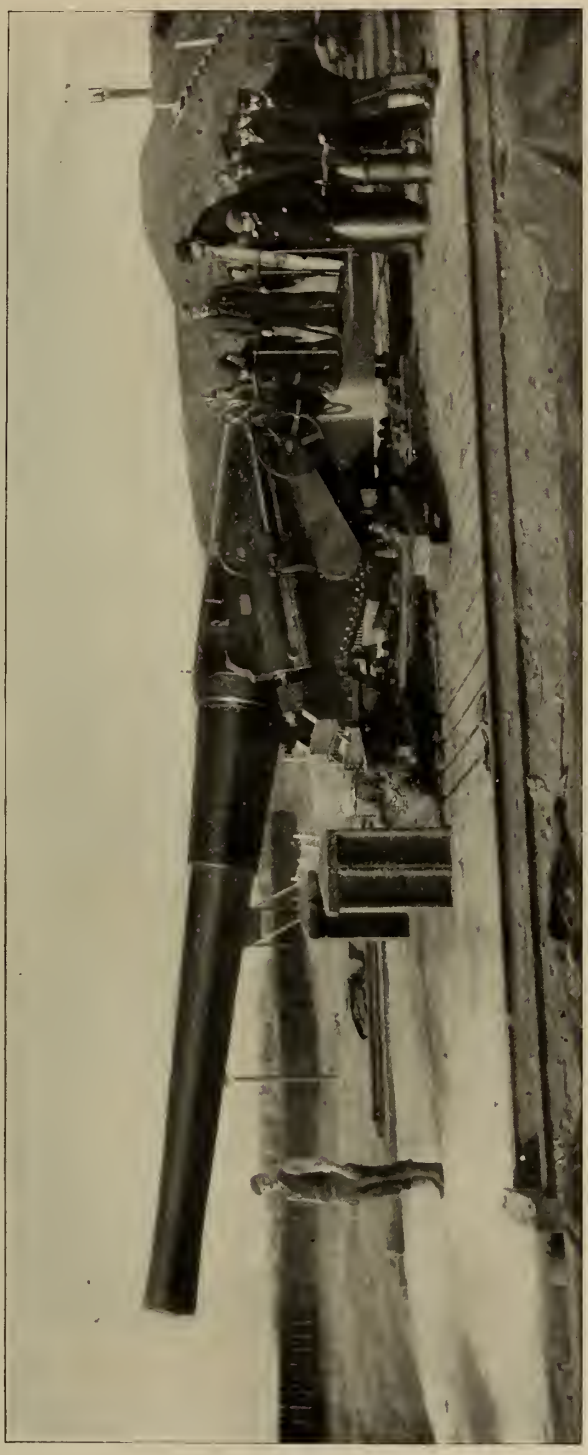


THE FIRST U. S. ARMY 10-INCH BREECH-LOADING STEEL RIFLE, MADE AT THE WATERVLIET, N. Y., ARSENAL, 1891.

The United States War College has pointed out that there are certain places on the country's coasts that have no great commercial importance, and consequently do not enter into the scheme of coast defence by the War Department, that would yet be of vital importance to the fleet in time of war. These places are not now defended in any way, and it would be necessary to place them in such a state that they could shield and protect any colliers or supply vessels that might be collected there to await the arrival of the fleet.

There can be no doubt that "the ship and fort are both essentials in national defence," and equally certain is it that no defence can be complete without the strongest possible offensive marine force. The purpose of this article, however, is more especially to describe the heavy ordnance mounted in American seacoast fortresses, the circumstances that have led to its supply

EIGHT-INCH RIFLES IN THE WATERVLIET GUN SHOP.



A BRITISH, ARMSTRONG-WHITWORTH 9.2-INCH BREECH-LOADING RIFLE ON HYDRAULIC RECOIL CARRIAGE.

and manufacture, with pictorial reference as well to the monitor type of heavy gun carriers that form so important an element of United States marine defence.

A British tactician has divided the artillery armament of a fortress into three parts:—

The heavy guns intended for direct fire.

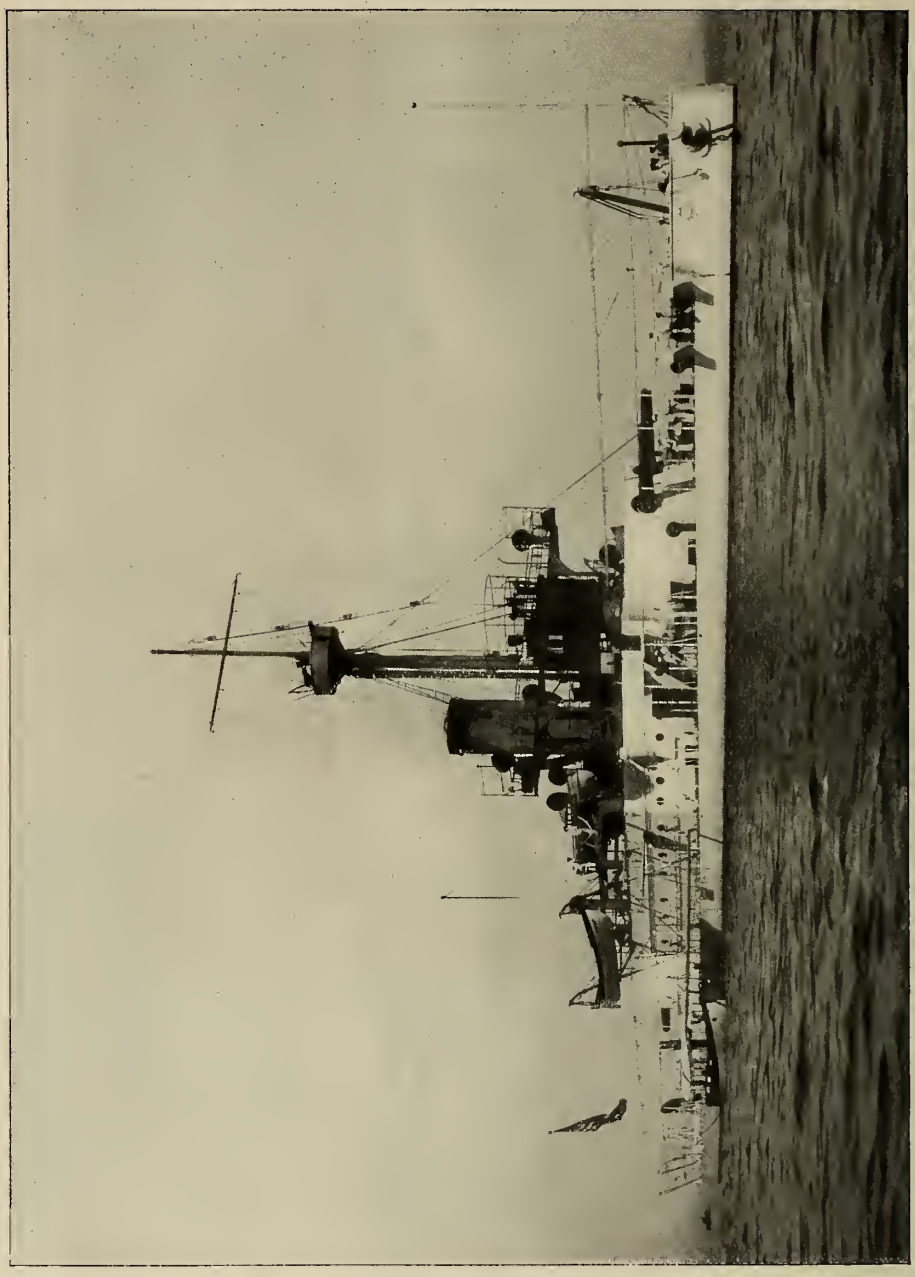
The howitzers for high angle fire.

The light armament for the protection of the mine-fields.

It is to the first and second that the writer shall give especial attention.

In considering the type of heavy ordnance now in use and under construction in the United States and the method of manufacturing it, a short historical review of the situation will be interesting, particularly as the few facts that will be presented mark the conceptions and determinations of the supply not only of American modern ordnance, but of the means for its fabrication.

When the annual naval appropriation bill was passed in 1883, Congress authorised the President to select from the army and navy six officers to constitute a board for the purpose of examining and reporting to Congress which of the navy yards or arsenals owned by the government had the best location and was best adapted for the establishment of a government foundry; or what other method, if any,



FROM A COPYRIGHTED PHOTO BY A. LOEFFLER, N. Y.

THE UNITED STATES DOUBLE-TURRET COAST DEFENCE MONITOR "AMPHITRITE," CARRYING FOUR 10-INCH GUNS.

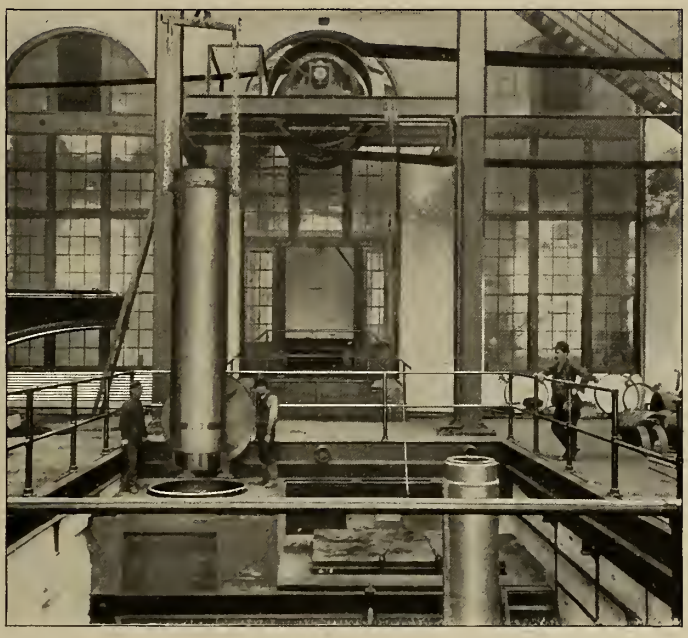
should be adopted for the manufacture of heavy ordnance, adapted to modern warfare, for the use of the army and navy of the United States.

Under this provision he appointed Commodore Edward Simpson, United States Navy; Captain Edmund O. Matthews, United States Navy; Colonel Thomas G. Baylor, Ordnance Department, United States Army; Lieutenant-Colonel Henry L. Abbot, Engineer Corps, United States Army; Major Samuel S. Elder, Second Artillery, United States Army; and Lieutenant William H. Jaques, United States Navy. The writer, in addition to being a member, was appointed secretary of the board.

In June, 1884, he published a treatise on ordnance, entitled "The Establishment of Steel Gun Factories in the United States," introducing the subject by the following extract from the board's report:—

"Before the introduction of rifled cannon, and the use of steel as the material for their construction, the United States boasted of her Dahlgren and Rodman cast iron guns, which were the models for imitation and the standards for comparison of all nations. While the rest of the world has advanced with the progress of the age, the artillery of the United States has made no step forwards. Its present condition of inferiority is only the natural result of such want of action."

The United States at this time had no heavy ordnance, except the cast iron relics of the Civil War,—in fact, no appreciable amount of modern ordnance of any kind, and was completely destitute of means to produce the forged steel type that at this time gave evidence of becoming a standard.



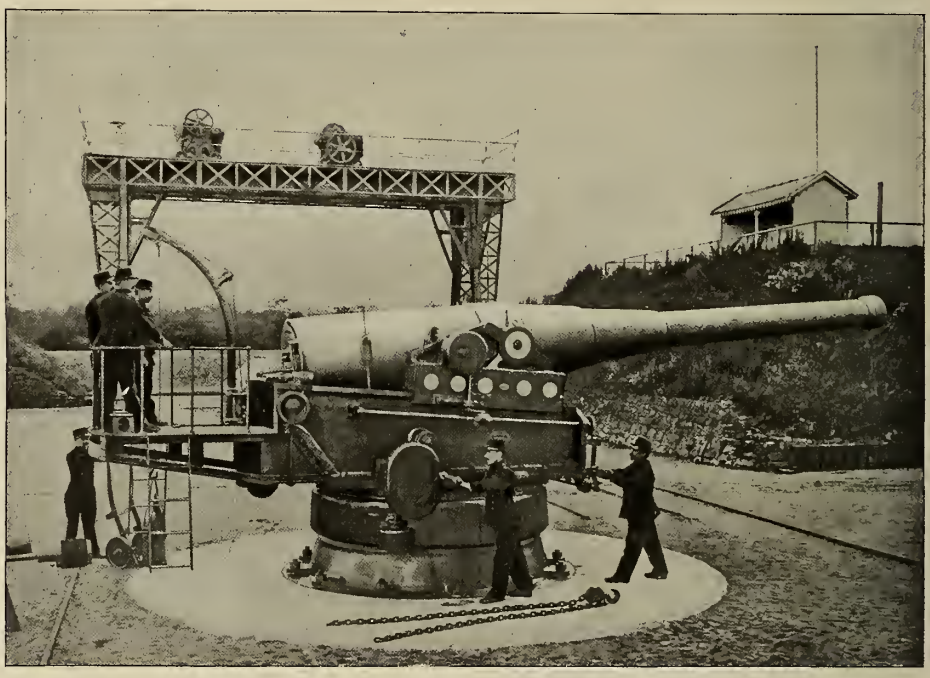
JACKETING A GUN AT THE WATERVLIET, N. Y., ARSENAL.

Great Britain possessed large numbers of wrought iron coiled muzzle-loaders, but was conducting extensive experimentation which left no doubt that the use of wrought iron and the system of muzzle-loading had been abandoned, and that in their places a system of construction would be adopted suggested by Mr. Vavasseur, which

consisted of a tube as thin as was consistent with strength, a long jacket shrunk on to provide longitudinal strength, and layers of superimposed cylinders, or hoops, shrunk on, the number of layers varying with the size of the gun; a breech-loading system, of the interrupted screw type, engaging in the jacket, and employing the De Bange mechanism for checking the gas.

French heavy ordnance comprised a large number of breech-loading coast defence guns, their cast iron bodies tubed and hooped with steel. They were fitted with the French interrupted screw fermature and the De Bange gas check. The list of guns of the marine artillery comprised a large number of calibres; and the variety in their construction showed the growth and development of the idea which finally resulted in an armament for the navy of guns constructed entirely of steel, including calibres of from six to sixteen inches.

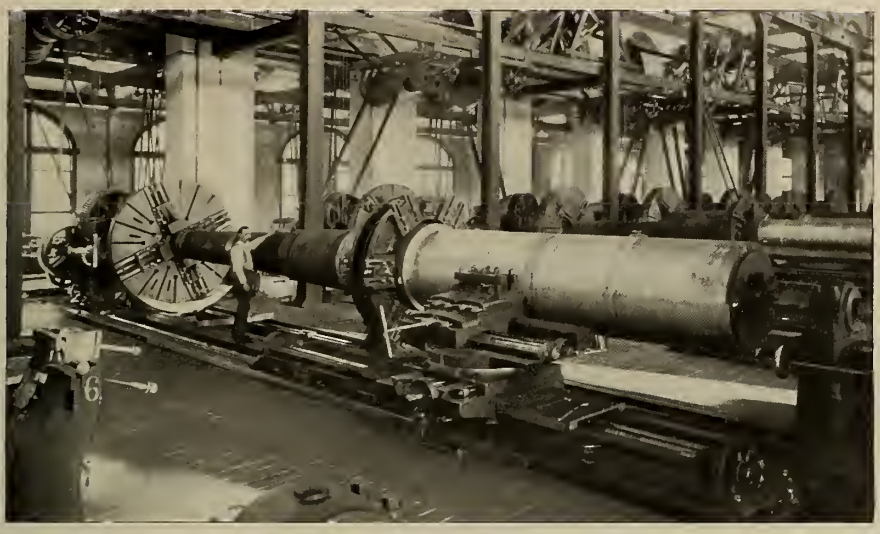
Germany was producing the heaviest and most modern gun, her steel breech-loaders having reached the 109-ton, 16-inch, 35-calibre long coast defender. Her main supply was drawn from one private firm, that of Krupp. Steel was used in their construction, and the system was one of built-up forgings. The breech mechanism and gas checking devices were radically different from those already mentioned, being the modified cylindro-prismatic wedge and ring originally invented by Mr. Broadwell, the latter still bearing his name.



A SCHNEIDER 11-INCH 30-CALIBRE BREECH-LOADING FRENCH COAST GUN ON CENTRAL PIVOT, HYDRAULIC CARRIAGE.

Russia had been for many years an extensive purchaser of cannon from Krupp, but having adopted the Krupp gun for its armament, it had proceeded to manufacture on that system for its own uses. Wire construction was experimental in Great Britain, France and Russia, France at that time having given it the most attention.

In 1884 the writer published a handy volume on heavy ordnance, in which he made certain recommendations which

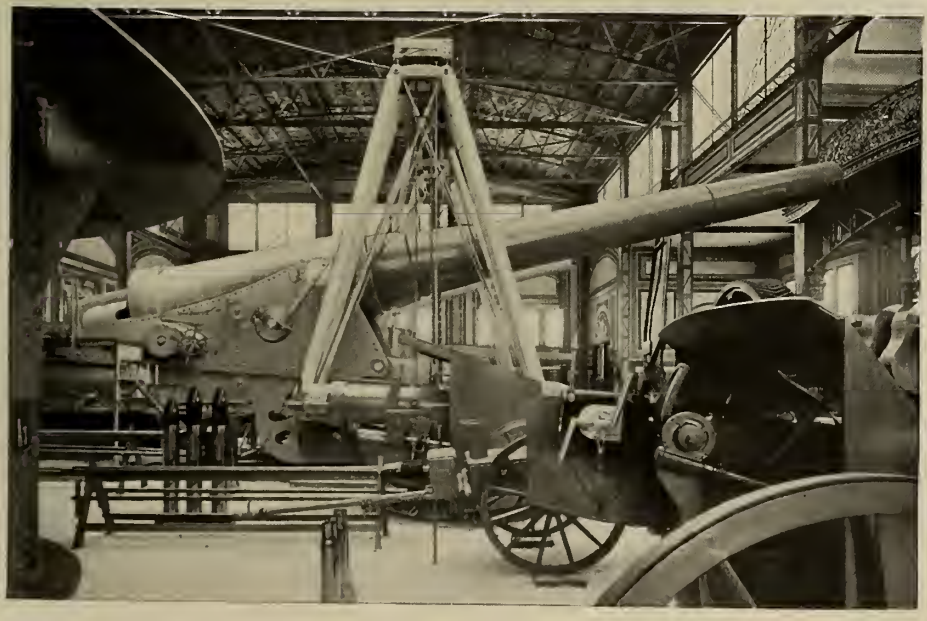


FINISH-TURNING A GUN AT THE WATERVLIET, N. Y., ARSENAL.

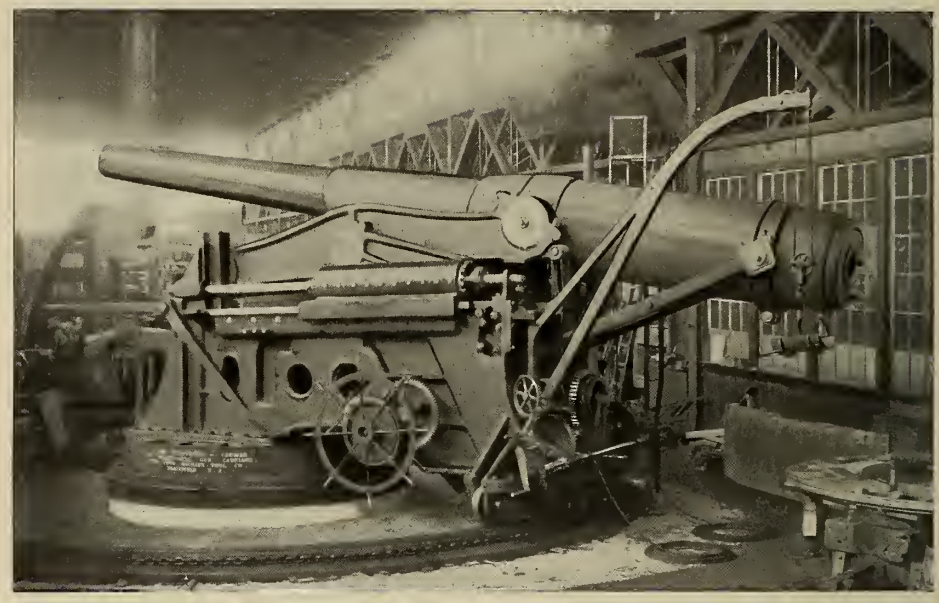
were endorsed a year later by the United States Senate Committee on Ordnance and Warships. His conclusions at that time were:—

"Guns should be made of hydraulic forged, open-hearth steel, breech-loading, chambered, of calibres ranging from six to sixteen inches, and from 30 to 35 calibres long.

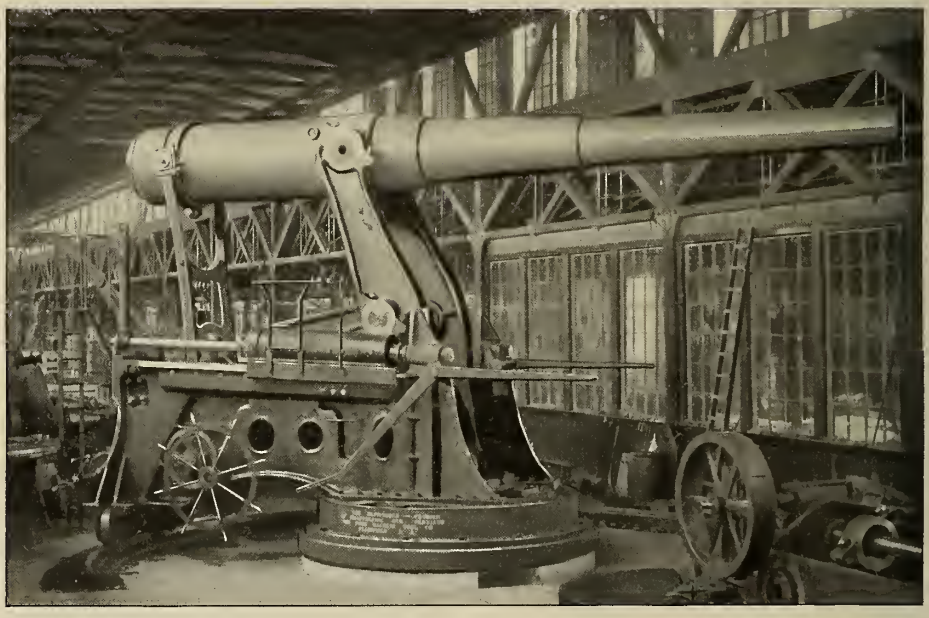
"With adequate appropriations, to be expended under the direction of an advisory board, confirmed by Congress;



HEAVY ORDNANCE MANUFACTURED BY KRUPP, OF ESSEN, FOR GERMAN COAST DEFENCE.



TEN-INCH BUFFINGTON-CROZIER DISAPPEARING GUN CARRIAGE IN LOADING POSITION.



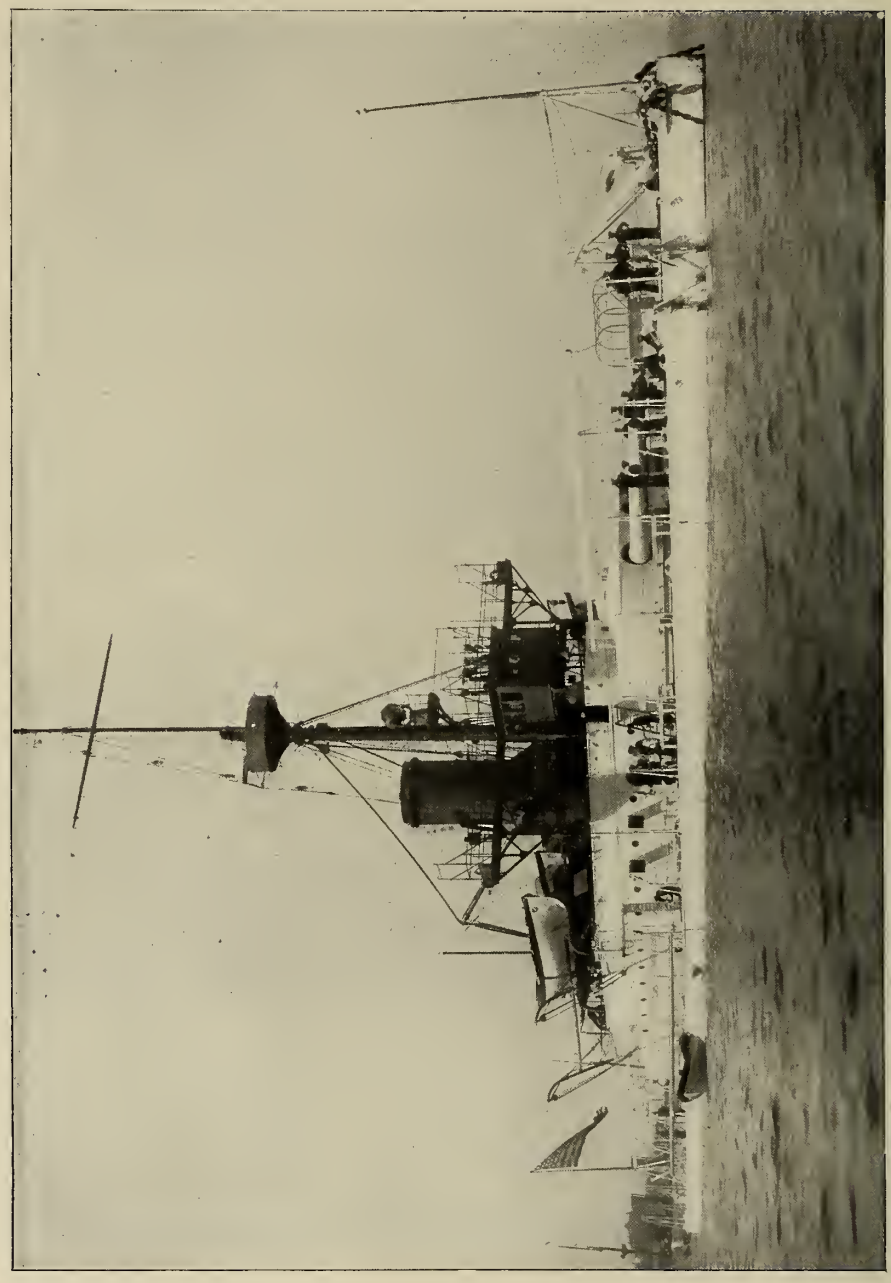
TEN-INCH BUFFINGTON-CROZIER DISAPPEARING GUN CARRIAGE IN FIRING POSITION. MADE BY THE POND MACHINE TOOL CO., PLAINFIELD, N. J.

with the understanding that the remuneration of the steel manufacturers shall be derived solely from the price paid by the government for the material after passing the tests required; and with the establishment of the two gun factories, as recommended by the Gun-Foundry Board, the United States will no longer be destitute of a means of providing proper ordnance for modern warfare, but will see her private industries producing the best gun and armour material in the world, and her gun factories equal to every demand made upon them, and her guns again the models for imitation and the standards for comparison of all nations.''

THE BRITISH METHOD OF PLACING BATTERIES OF DISAPPEARING GUNS AND HOWITZERS.

In 1886 the writer resigned his commission in the naval service and had the unique opportunity of carrying out in civil life the recommendations which he had made as an officer. He became the ordnance engineer of the Bethlehem Iron Company, inaugurated and assisted to develop their ordnance plant, introduced into the United States and established at Bethlehem the Whitworth systems of liquid compression and hydraulic forging of steel, and when, a short time ago, he severed his connection with that useful corporation, he had the satisfaction of seeing his prophecy of 1884 an accomplished fact; for to-day American "private industries are producing the best gun and armour material in the world," and are "standards for comparison of all nations." The country lacks only quantity.

At the beginning of 1891 the United States sea-coast artillery in hand consisted of two 8 inch and one 10 inch steel breech-loading rifles and one 12-inch cast iron mortar, hooped with steel. There were other guns, but they were mere relics of the Civil War, twenty-six years previous, and were of little more use than for comparative

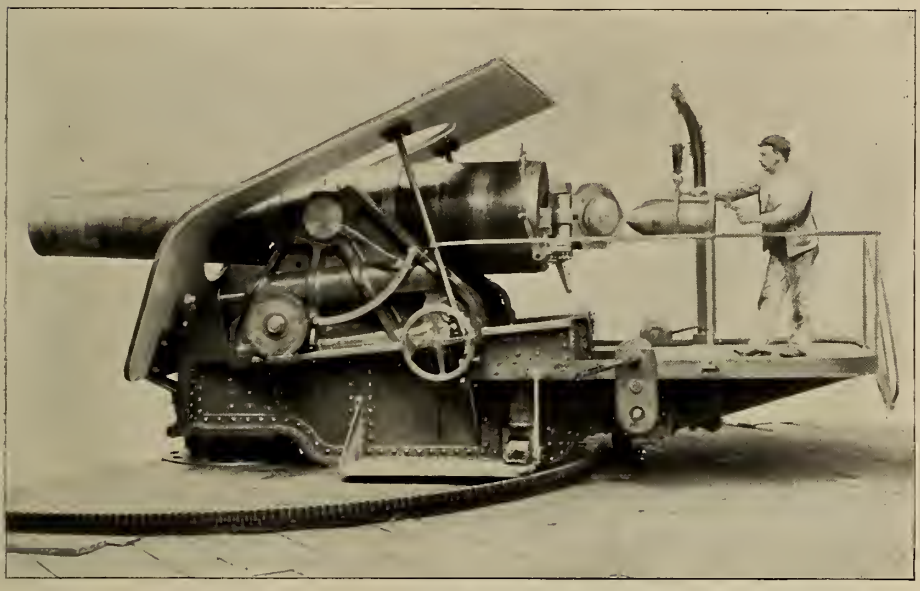


THE UNITED STATES DOUBLE-TURRET COAST DEFENCE MONITOR "TERROR," FOUR 10-INCH GUNS.

museum purposes. Contracts had been concluded, however, with domestic manufacturers for steel forgings for field, siege and sea-coast guns; for the fabrication of eleven 8-inch steel rifles, and for seventy-three 12-inch mortars. This outlook had led Americans to view the surroundings of the question with less anxiety than three years before, and even to encourage them to accept the situation as a happy contrast.

Although this additional ordnance had been authorised, it was not until two hundred, the large majority being of the forged, built-up, all-steel type; a goodly number in comparison to what the country had in 1891, but still a quantity absolutely inadequate for the defence of the principal cities along the great coast frontier.

The contract of November, 1891, was considered at that time by the Board of Ordnance and Fortifications as placing the matter of coast defence in a more favourable light than ever before. It certainly was an initial move of great



AN ARMSTRONG-WHITWORTH 11-INCH BREECH-LOADING HOWITZER IN LOADING POSITION.

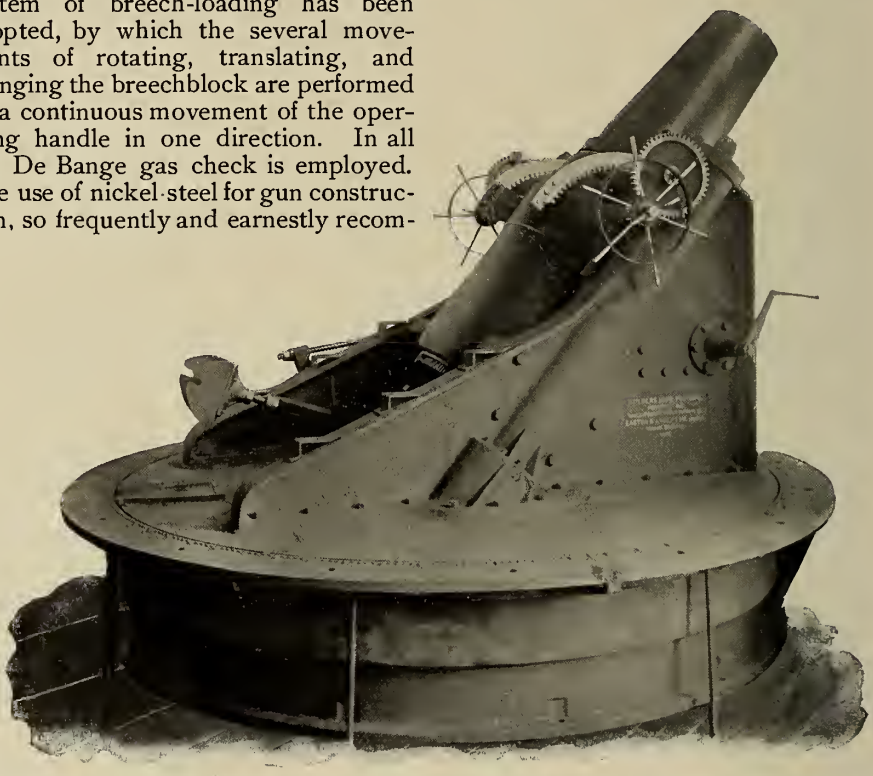
November, 1891, that the writer saw his efforts fully rewarded by securing for the Bethlehem Iron Company the contract for 100 high-power coast defence guns of 8, 10 and 12-inch calibre. This was practically the commencement of a definite policy on the part of Congress to provide the means for a suitable defence of the American coast with modern high-power guns. To-day there are about one hundred each of 8-inch and 10-inch, nearly fifty 12-inch, all high-power, steel, breech-loading guns, while of 12-inch breech-loading mortars the United States have over

value. The construction adopted for these guns and mortars consisted of tube, long jacket and several layers of hoops, the various elements shrunk into place.

A later-type 12-inch rifle, known as the model of 1896, was constructed with a view to secure somewhat greater tangential resistance to bore pressures and consisted of a tube first hooped throughout its length; then a very long jacket was shrunk on, forming the third layer; and finally a fourth layer of hoops was shrunk on over the breech. The principal objections to this model

are the difficulty of assembling the long jacket by shrinkage and the impracticability of removing the jacket should it become fast before reaching its home position. These difficulties might be met by assembling the gun by the Gledhill process of forcing the taper-turned and bored parts into place by hydraulic pressure.

In both the high-power rifles and the 12-inch mortars the Canet-Whitworth system of breech-loading has been adopted, by which the several movements of rotating, translating, and swinging the breechblock are performed by a continuous movement of the operating handle in one direction. In all the De Bange gas check is employed. The use of nickel-steel for gun construction, so frequently and earnestly recommended by the writer, is now largely employed not only in the United States, but in Europe as well. The most important new construction that has been entered upon in the United States is the type 16-inch gun, the principal forgings of which will be made of nickel-steel.



A 12-INCH U. S. COAST DEFENCE MORTAR AND CARRIAGE. MADE BY THE BUILDERS' IRON FOUNDRY, PROVIDENCE, R. I

Of the methods employed for producing the steel parts that are assembled at the government gun factories at Watervliet and Washington the Whitworth processes, developed by Mr. Gledhill, are the surest and most economical. The steel is made by the open-hearth process, the metal being melted on an open hearth instead of in closed pots or crucibles. During the progress of the melt, samples are tested chemically and mechanically to determine the exact condition of the bath. When satisfactory, the steel is tapped into ladles and thence into a mould where it is compressed in its liquid state by hydraulic pressure.

The ingots are made as large as possible to improve the steel and facilitate subsequent operations. These ingots are cut into blocks of sizes required for the tubes, jackets and hoops of the various calibres. In the case of heavy tubes and jackets the ingots are bored before they are forged to their required dimensions, but in the case of hoops

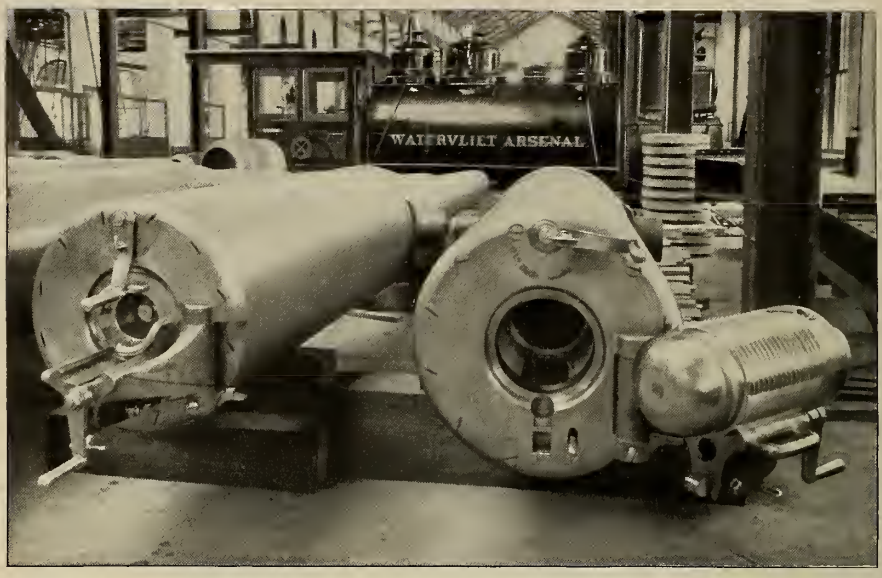
A 10-INCH DISAPPEARING GUN CARRIAGE. MADE AT THE NILES TOOL WORKS, HAMILTON, OHIO.

and smaller jackets the blocks are punched before enlargement.

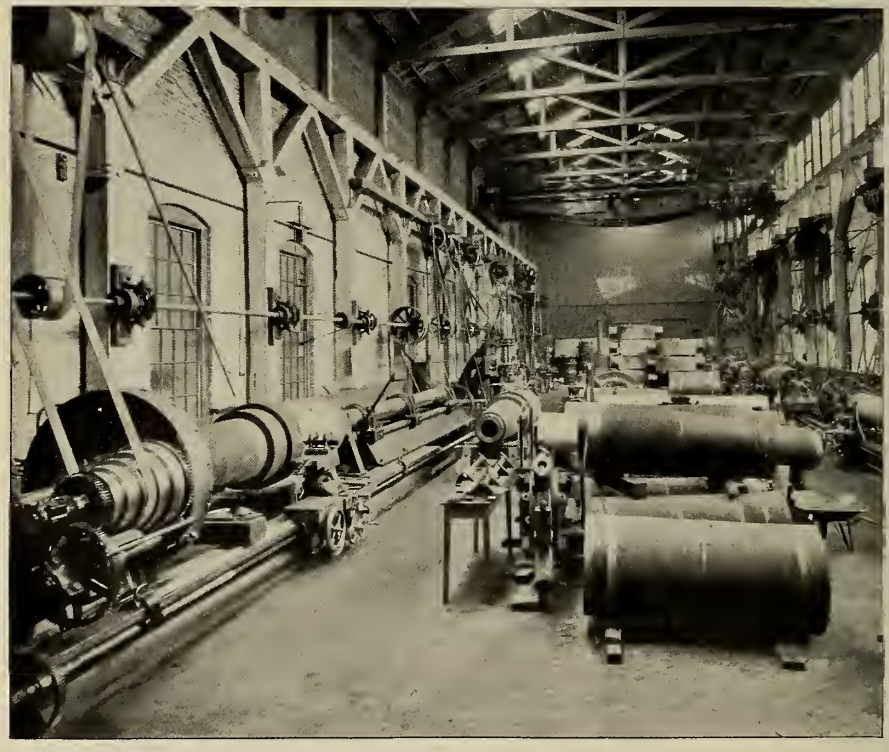
The most efficient mechanical instrument for shaping all the gun parts is the Whitworth hydraulic forging press, and the methods inaugurated by the writer at Bethlehem are still employed. These hydraulically-shaped parts are rough-turned and bored, oil-hardened and annealed until the exact physical requirements are secured, small specimens being cut out and mechanically tested to determine the modulus of elasticity, elastic limit, elastic elongation, tensile strength and contraction of area.

In this shape and condition the forgings leave the steel works and go into the gun shops for the fine mechanics of finish-turning, boring, assembling, chambering, breech-fitting and sighting. The operations are many and some of them delicate, but when the gun is finished it can be relied upon as a perfect instrument, for if there had been any chemical defects in the production of the steel they would surely have been discovered at some one of the many operations of machining and assembling.

The various methods of mounting and protecting heavy ordnance can perhaps be best defined by referring to the nomenclature which the War Department has adopted for its carriages. The barbette, sometimes called non-disappearing, and the casemate, often described as the minimum port, carriages depend upon the strength of the barbette or casemate for the protection of the guns and carriages, and it must not be forgotten that these systems protect only those portions of the guns that are within the barbette or casemate



THE BREECH ENDS OF SOME 8-INCH RIFLES AT WATERVLIET ARSENAL.



TWELVE-INCH COAST DEFENCE MORTARS IN THE SHOPS OF THE NILES TOOL WORKS CO., HAMILTON, OHIO.

ports, and afford most excellent targets, susceptible to accurate machine gun attack.

Most of the heavy coast defence guns are mounted on disappearing carriages of the grasshopper or Moncrieff type, modified and known in the United States as the Buffington-Crozier carriage. They are adapted to limited or all-round fire, in accordance with the emplacement.

The mortars are mounted on hydraulic spring-return carriages, but depend for their invisibility upon their position, which should be behind natural or artificial elevations, made to harmonise with the surrounding country. They are in absolute security, their crews are under cover, they are fired from firing stations long distances away, and if smokeless powder is used their location can be defined only with great difficulty.

Mortar batteries are acknowledged to be one of the most important factors in the defence of harbours and positions of vantage, and practice with them has reached such a high standard of proficiency that no fleet would dare attempt the advantages of greater accuracy that an anchorage would secure over the attack of a fort while under way. The destructive effect of the vertical fire of a 12-inch shell upon the thin deck of a ship can be readily imagined.

In addition to the batteries of 8-inch, 10-inch and 12-inch guns, mounted on gun lifts and disappearing carriages, the principal American seaport of each coast is additionally protected by a gun battery and plant of novel character, the pneumatic dynamite gun, the efficiency of which, like the submarine torpedo-boat, remains to be tested.

At Sandy Hook, New Jersey, and at Fort Winfield Scott, California, there have been erected groups of three 15-inch pneumatic dynamite guns, of 40 calibres length, to fire projectiles adapted to charges varying from 500 to 100 pounds of explosive gelatine, with ranges, respectively, of 2000 to 5000 yards. While these two products of persistent engineering minds are still novel for the reason that they have had no actual battle test to determine their efficiency, the conceptions and attempts to perfect them are very old. And even now that the United States are engaged in actual warfare, fortune has kept the enemy too far away from these two wealthy centres to discover the value of the pneumatic coast guns, and the Holland submarine torpedo-boat has not had opportunity to exercise her moral effect and actual abilities in a character of naval work of which the success so largely depends upon invisibility and the power to attack from underneath.

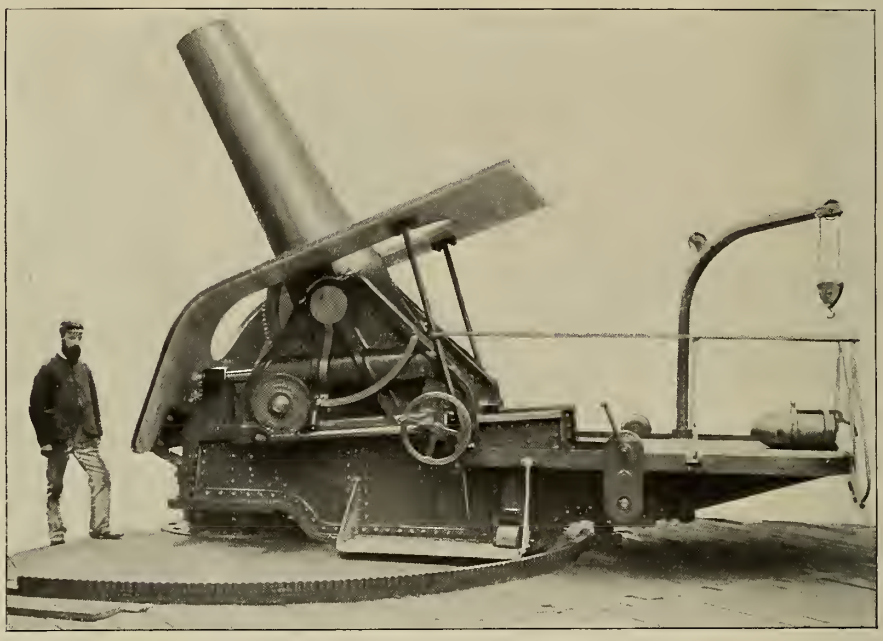
A 6-INCH ARMOUR-PIERCING SHELL WHICH PERFORATED 6 INCHES OF CARBONISED NICKEL-STEEL ARMOUR. MADE BY THE WHEELER-STERLING CO., PITTSBURGH, PA.

The reported terrific destruction effected by the explosion of the high explosive shells of the United States dynamite cruiser *Vesuvius* at Santiago, when she was at last permitted to test their power, has marked the era of the general adoption of means of throwing

high explosives both from fortress and ships, and the control of invisibility that has been obtained in the Holland boat has provided reliable means of securing the objects for which the torpedo-boat was designed. What an insurance and moral protection the United States would have against attack if she possessed a dozen submarine boats fitted with 18-inch torpedoes and 20-inch high-explosive guns. They could be built in six months for less than the price of a battle-ship.

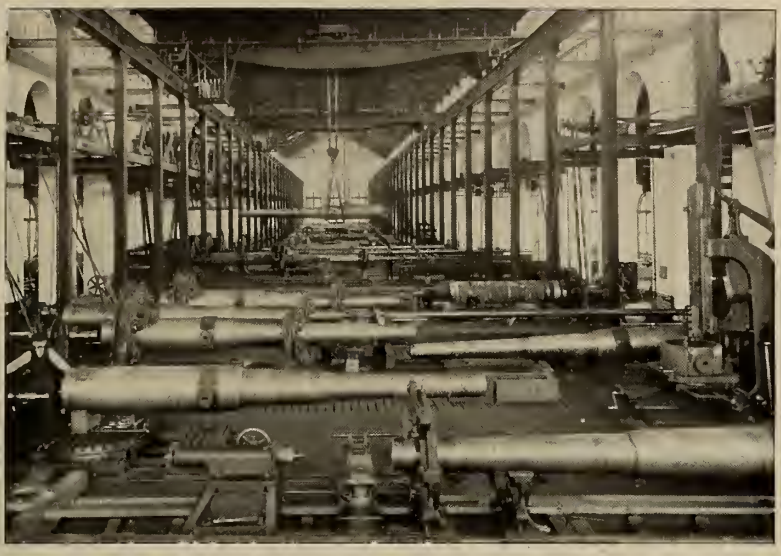
With the completion of the emplacements and batteries and the mounting and equipment of the guns and mortars comes the provision for their care. This has been justly considered as of such importance that the fortifications appropriation bill, approved in March, 1897, carried a provision that prior to any expenditure for the construction of buildings connected with the new fortifications the Secretary of War should report to Congress the most practicable and economical plan for the care and preservation of the fortifications and their armament.

In this connection, General Miles, commanding the United States Army, pointed out how unwise it would be to spend many millions of dollars for batteries and effective ammunition and then omit to provide the means of properly caring for and keeping them ready for immediate service, and made the concise and practical recommendation that "wherever a battery of high-power guns and mortars is located, arrangements should be made for placing a sufficient number of soldiers there to care for them and fight them whenever emergency requires."



A BRITISH, ARMSTRONG-WHITWORTH 11-INCH BREECH-LOADING HOWITZER IN POSITION FOR HIGH-ANGLE FIRE.

Two additional regiments of artillery have been authorised by Congress, but it will not be difficult to realise how inadequate the force still is when it is recalled that in January last there were twenty-six important batteries in fifteen States at which no troops were stationed, and for which the authorised strength of the artillery force of the



A SHOP VIEW AT WATERVLIET ARSENAL.

United States Army was inadequate to provide.

Had the demands and petitions for a proper sized naval reserve been heeded, and a force averaging a thousand men per State been authorised, batteries of them, instructed by the regular artillery in time of peace, would have provided a splendid seacoast defence force that, with submarine torpedo-boats, would have released the regular artillery and the northern coast squadrons for immediate service in Cuba and Porto Rico.

Although requiring so long a time to make, and each element so seemingly costly in comparison to its ammunition, heavy ordnance constitutes a small part of the concrete whole of defence in comparison to the amount of powder and shell used in actual warfare. It is to this branch of supply that the United States ordnance departments have to apply their energy and forethought. In the present instance, for the supply of powder alone, every factory has been working full, if not overtime, for many weeks.

Of the supply of projectiles, Commodore O'Neil, Chief of the Bureau of Naval Ordnance, has stated that the daily output of heavy calibre has reached 3000, while the capacity of several factories for the smaller calibre is practically unlimited; in fact, that the present supply will not only meet all demands of the American fleets and forts, but will quickly provide a reserve to meet any possibilities of the destruction of the factories by accident or design.

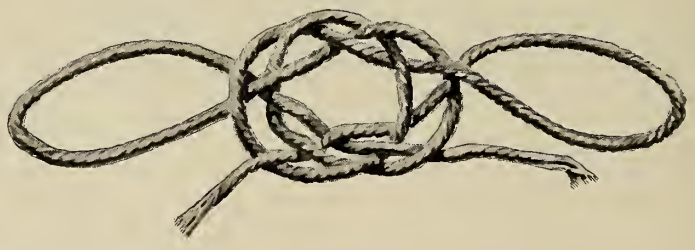
The almost unanimous international agreement to do away with privateering, and the small percentage of Spanish shipping upon the seas have given the commerce-destroying type of cruisers, or auxiliary cruisers, little else to do than serve as scouts and transports, while coal being a contraband of war, depriving Spain of any base of fuel supply, and the United States coast line being so far from the Spanish bases, there has not been felt in this war the absence of the present type of torpedo-boats which could be used only to assume, under favourable weather conditions, the offensive against a blockading fleet. In fact the uselessness of torpedo boats and torpedo-boat destroyers must be regarded as having been established by recent events. But the splendid work of the American monitors in the West Indies must have removed the doubts of the most

skeptical as to the value of the low freeboard coast defence ships. The writer's own experience many years ago, in a type much less modern, led him to strongly advocate them as a most valuable element of coast defence.

The unexpected possession of Manila, which was only the natural result of the destruction of the Spanish fleet and capture of the arsenal of Cavité by Dewey, was not only a great surprise to every one, but an earlier than usual disregard of the issues of the declaration of war; another of the many examples of how rapidly a declaration of war causes the issues to be thrust aside by the changed relations, or forgotten in the more exciting scenes that quickly follow. Even Spain could not have been more amazed when she realised that her Eastern fleet had been wiped out of existence in a few hours, her mines of no avail, and her principal Pacific port governed by an American admiral.

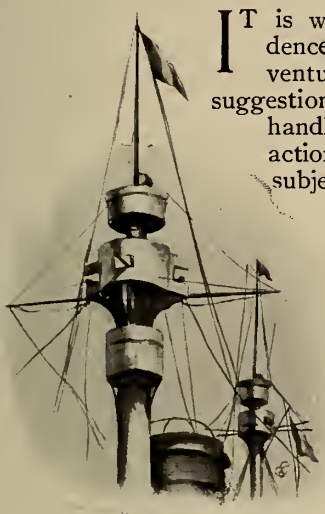
The impossibility of carrying on a war of philanthropy, or of attempting to provide food for a colony of reconcentradoes without directly sustaining the garrisons which the blockade was purposed to destroy, was very early demonstrated, and the unpreparedness of the United States became the more emphasised in that they could not follow up Dewey's success by a similar lightning-stroke possession of Porto Rico, and then concentrate their available forces, both of the army and navy, to effect the promised relief in Cuba.

Have we not already had sufficiently numerous and expensive lessons to forbid our ever in the future neglecting to provide a complete and adequate system of modern defences?



THE IDENTIFICATION OF WARSHIPS, AND FIRING DISCIPLINE.

By Sydney W. Barnaby, M. I. N. A., M. Inst. C. E.



IT is with great diffidence that the writer ventures to make any suggestions as to the handling of a ship in action, because the subject will hardly be considered as coming within the province of a naval architect. But although all questions of tactics and the formation of the line of battle must be left to the judgment of naval officers, it seems to me that there are others, such, for example, as the best methods of attacking particular ships concerning which it might be expedient for the naval officer to consult the naval architect.

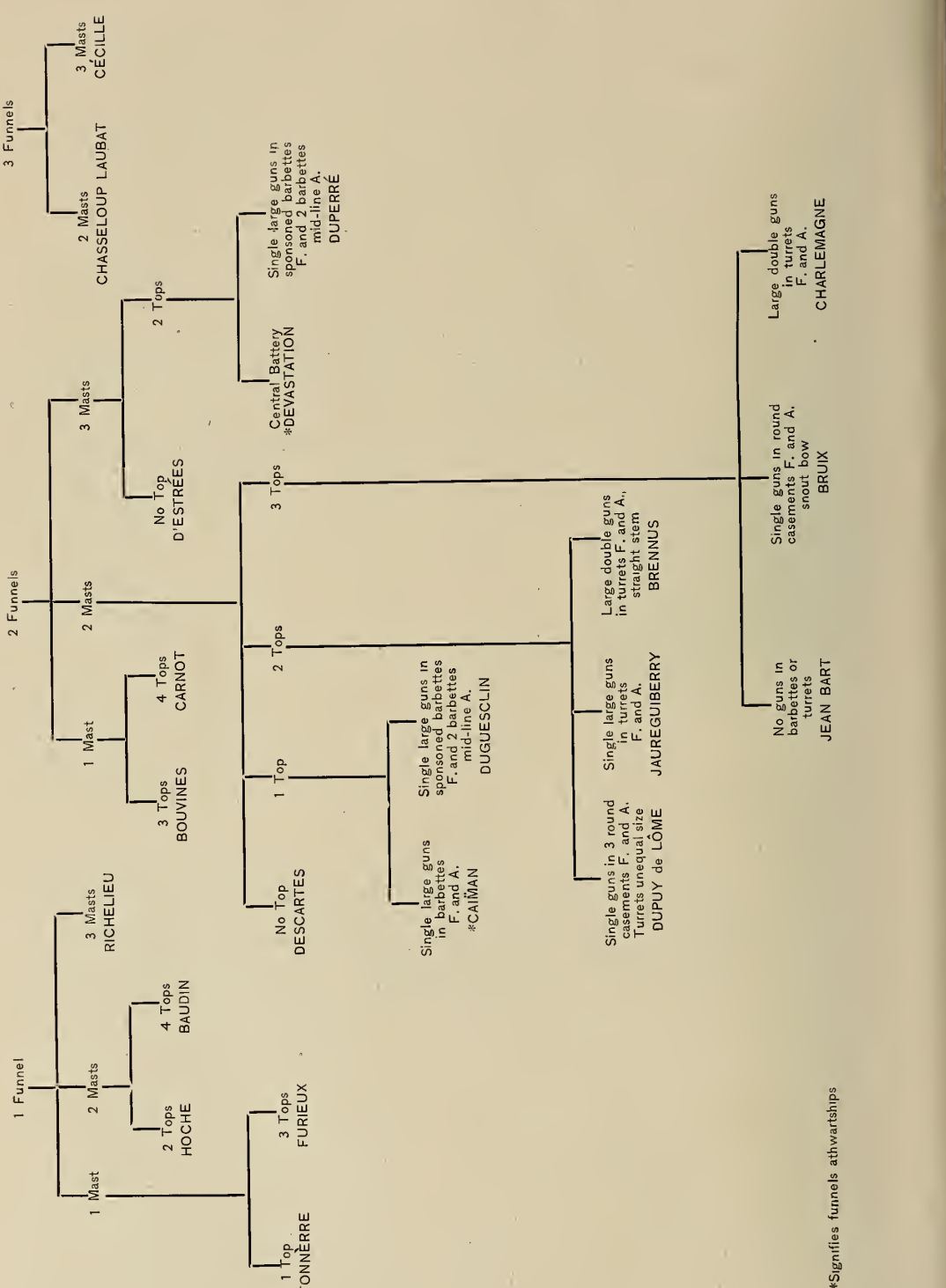
If the latter has before him a drawing showing the disposition of armour and the protection of guns and their mountings in any ship, his experience should enable him to detect the most vulnerable points and to suggest the kind of attack to which this ship would most readily succumb.

Although two vessels may be quite equally matched in offensive and defensive powers, yet one may very speedily obtain an advantage over the other if her firing discipline be superior. It does not by any means follow that this advantage would fall to the ship which most frequently hulled the other; much more would depend upon where the shots were placed and whether the size of shot was such as to do material damage to the part struck.

Thus, attack by light shot or shell upon a thick armour belt would be ineffectual, however well directed; and, again, heavy shot or shell, fired from the main armament of a battle-ship, would not be properly employed, as a rule, in attacking unarmoured positions. The only reason for putting guns of different calibre upon a ship is that the target presented to them by an enemy's vessel is not a homogeneous body. If it were, it would much simplify matters to have all guns alike. The big guns are for the hard places and the small guns are for the soft ones.

In the current volume of Brassey's Naval Annual there is an excellent article by Captain Orde Brown upon "Precision of Fire," and he very properly lays stress upon this point. He says:—

"There exists a school of men who . . . claim to take the practical view of what will really happen on service when all requirements will go to the winds. . . . It is idle, they urge, to contemplate the discriminate attack of a ship; that is, aiming at any special part, selected with a view to her particular structure. It is enough to fire 'into the brown,' as it is termed, in short, to hit her anywhere and apparently with anything. If this view is correct, our schools of gunnery, our designers, and our manufacturing departments are wasting time and energy. Nay, even the issue of different kinds of projectiles is a mistake, for the purposes to be attained by an armour-piercing shot and a common shell are widely different, and discriminate firing is contemplated



*Signifies funnels athwartships

in their issue, and a decision has to be made in naming the projectile in the very order to load."

It must be conceded that there is a proper target upon every enemy's ship for each of the different calibres of guns carried, and that these targets will vary according to the type of ship attacked. So much will depend upon the first few minutes of a close action that if a commander could give his instructions to his different gun detachments, before coming within close range, as to the part of the ship upon which they should direct their fire, it might be of immense advantage to him.

Before he can do this he must recognise his enemy, and every means would, no doubt, be taken to discover the identity of an opponent at the earliest possible moment. Brassey's Annual, the Pola Marine Almanack, and other publications supply means of identification, and a careful study of the sketches given in them, which might be roughly classified, should enable an officer to distinguish an enemy quickly.

For example, take the following list of forty-four French ships, of which illustrations are given in the annuals mentioned:—

Baudin.	Hoche.
Formidable.	Magenta.
Bruix.	Marceau.
Chanzy.	Neptune.
Charner.	Caïman.
Latouche Tréville.	Indomptable.
Chasseloup Laubat.	Requin.
Bugeaud.	Terrible.
Friant.	Richelieu.
Carnot.	Friedland.
Cécille.	Colbert.
Brennus.	Boudines.
Descartes.	Jemmapes.
Charlemagne.	Tréhouart.
St. Louis.	Valmy
Gaulois.	Dévastation.
Furieux.	Courbet.
D'Estrées.	Redoutable.
Tonnerre.	Jean Bart.
Duperré.	Alger.
Dupuy-de-Lôme.	Isly.
Jauréguiberry.	Duguesclin.

As the ships bracketed together are of the same class, a representative only of each need be considered. What is wanted is something resembling the admirable system adopted by M. Berthollet for the classification of the measurements of criminals. Let us arrange the ships, first, according to the number of their funnels, marking thus, *, those which have them disposed athwartships. In this way we get three columns, which can be subdivided according to the number of masts. We shall find remaining a group of nine ships having two funnels and two masts.

The next most prominent feature appears to be the number of fighting tops on the foremast. I prefer to take the foremast only, because, if the vessel is approaching end on, the tops on the mainmast would possibly be obscured by the funnels.

Under fighting-top subdivisions we shall have remaining no group containing more than three ships, and if we finally place each of the ships in these groups under headings denoting the disposition of the large guns, stating whether they are placed singly or in pairs, in turrets or in barbettes, and so on, we are able to construct a table like the one on the opposite page, in which all the ships will be separated.

Suppose a lookout at the masthead reports the following features in an approaching ship:— "Two funnels in a fore-and-aft line; two masts; three fighting tops on foremast; large double guns in turret forward."

If the ship is one of those tabulated, she will be made out from the table as one of the *Charlemagne* class. If "one funnel and three masts" are reported, she is the *Richelieu*, or one of her sisters. "Two funnels athwartships, two masts, one fighting top on foremast," distinguishes the *Caïman* class, and so forth.

Of course, this assumes that the "strange ship" is one of those embraced in the table. These are selected only to show the proposed method. The table can always be extended to include a greater number of ships, and further subdivision can be introduced; but it would not be necessary always to carry this to the point of isolation. Groups of two or three ships could be resolved by reference to the sketches, when differences of bow and stern, and in the spacing between masts and funnels and other features would give the

necessary clue to identification. The features selected in the table are taken in the order in which they would be distinguishable. The smoke from the funnels would probably enable them to be counted at least as soon as, if not before, the masts, and they are features which would not be altered when the ships are cleared for action.

In peace manœuvres some officers have taken great pains to disguise their ships by fixing up sham funnels, painting lines on them, and so on; but it is doubtful if this practice is ever likely to be resorted to in war.

It would have been convenient if some means could have been found of distinguishing at once a battle-ship from a cruiser, but this does not seem practicable. In the British Navy cruisers, both armoured and protected, are generally distinguished by raking masts and funnels, while those of battle-ships are upright. Exceptions, such as the *Diadem* and *Powerful* classes, are known by their four funnels. But this distinction does not apply to the French Navy.

It is possible that the different Intelligence Departments have already provided officers with some such scheme as that sketched out here, but if they have not done so, an officer could readily prepare such a table for himself. It would be well to take every opportunity of checking the correctness of the tables when foreign ships are met on service, as ships are frequently refitted and are sometimes altered considerably in the process. Moreover, the authorities do not always agree, especially as to the number of fighting tops in some vessels.

Let us suppose the enemy's ship, or at any rate the class to which she belongs, is known! Then if the captain could turn to his note-book and find a prearranged plan of attack, suited to her construction, he could at once tell the guns' crews what their target was to be. There are, for example, several completely belted ships in the French Navy, which would be in serious danger of capsizing if a certain number of large holes were made above the belt at the fore part. These ships, steaming head to sea, may pile up water, entering through shot holes, to such an extent upon the armour deck as to endanger their stability.

While the heaviest of the guns, therefore, would attack the belt amidships, if powerful enough to penetrate it and disable the machinery, lighter shell fire would be directed upon the bow just above the belt, with the additional chance of setting fire to woodwork in seamen's quarters. A fire taking place forward would probably be more serious than one in the after part of the ship, as the smoke would be more embarrassing.

Again, in many ships there are heavy guns, mounted in turrets or barbettes, which have no protection to their bases. Large shells, exploded under the turret or barbette, would be nearly certain to disarrange the guns or loading gear, and even comparatively trifling damage to the structure supporting the turret might make it dangerous to fire the heavy guns in it.

It is always a satisfaction to a designer if he can fire the heavy guns in his turrets without damaging the mountings, and one or two 6-inch shots, passing through his nicely calculated structure of struts and webs and brackets, might do such mischief that repeated discharges of the guns would wreck the whole thing. There are ships, again, which have large guns traversing so closely over a thin deck that a shell, judiciously placed under the deck, might blow it up in such a way as to lock the gun, or, at any rate, prevent it from changing from one side to the other.

On the principle that the best defence lies in a superiority of fire, all exposed guns would naturally form the object of attack from the light armament. The men in some of the French barbettes are very much exposed and invite attack from quick firers in tops. Guns mounted on an upper deck, protected only by shields, might be upset by shells exploded under the deck, and the target covering the dangerous zone under the gun would be a larger one to

fire at than that presented by the gun itself.

These are thrown out only as suggestions as to the lines upon which "firing discipline" might be based. Captain Brown says, in the article already mentioned, that a rule has been suggested by naval officers for the attack of an unrecognised adversary, which is as follows:—

"With the exception of a few Q. F. pieces, let all guns fire with common shell at the hull near the base of the foremast a little above the water-line. The Q. F. pieces above mentioned should fire at any deck structure before the funnels or about the foremast. The object is to pour in common shell where they will tell on nearly all armour-clad ships as well as cruisers, and to confine the executive staff inside the conning tower and cripple the direction of the ship as much as possible."

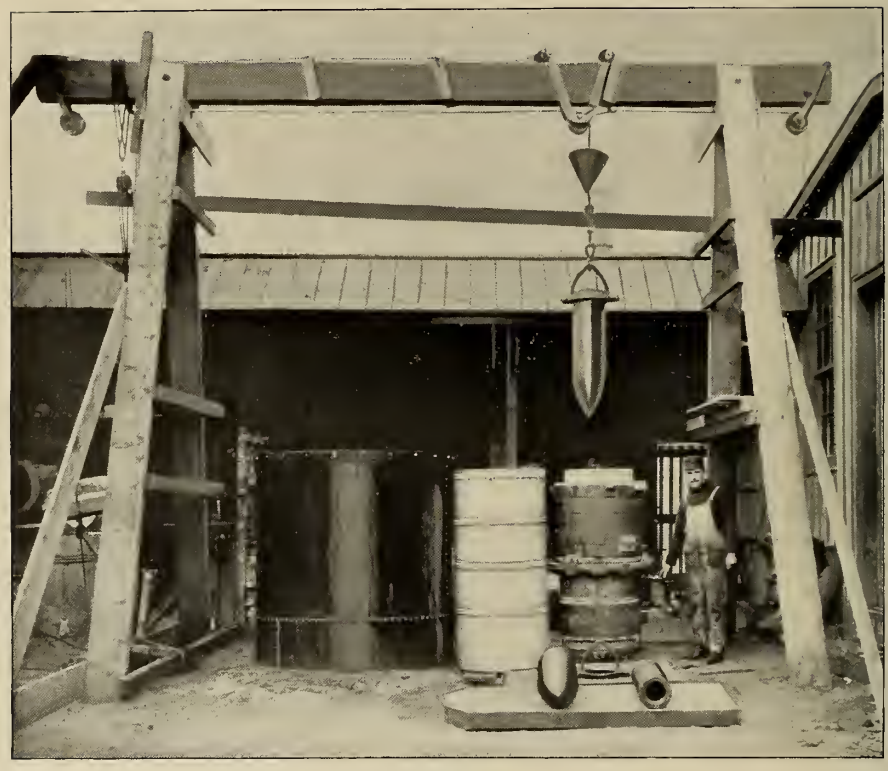
The need for similar rules for discriminate fire upon known ships is what I am now suggesting. Captain Brown states that the results of naval practice at a small target show that the hits from each class of B. L. gun average about 30 per cent. of the rounds fired, and he apparently sees no great difficulty in planting shots near any desired spot on the side of a ship.

This article was draughted before I saw what Captain Brown has written on "Precision of Fire," and before I knew that he was working in this direction at all, and I feel encouraged in putting forward these suggestions after finding them supported by a gunnery officer of such experience.

It may be that duels between ships will be of rare occurrence, and that such actions as that at the Yalu will be the most frequent, where fleets will pass each other rapidly and where such rules as I propose for discriminating attack could not be put in practice. But is there not still the chance that individual ships may be pitted against each other when it will be worth while to "fight with the head?" Even at the Yalu, towards the close of the action, where a ring was formed around the two Chinese battle-ships, an opportunity for some scientific sparring probably occurred.

HARDENING PROJECTILES BY GAS.

By E. P. Reichhelm.

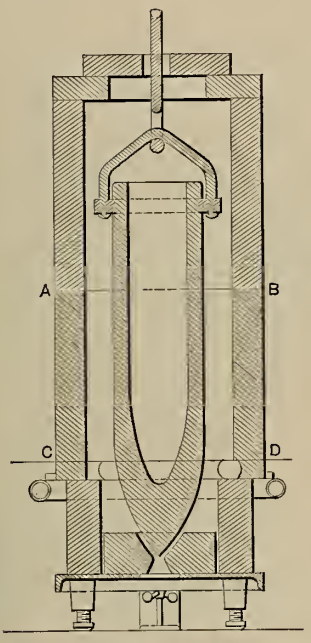


REMOVING A PROJECTILE FROM A GAS FURNACE.

THE present war between the United States and Spain has naturally stimulated all American industries whose product can be utilised in national defence, and to meet the demands of the United States government for guns and ammunition some manufacturers who never thought of dealing with the Government in these lines have been brought into requisition. The necessity for doing promptly whatever was to be done has compelled contractors in the ordnance line to seek the aid of all available talent in improving their facilities, and one result of this was the recent installation, for the Driggs-Seabury Gun and Ammunition Company, of Derby, Conn., of a gas furnace plant for heating large projectiles for hardening. An experimental plant was first erected by the American Gas Furnace Company, of New York, after a plan devised by the writer, and the success of this was apparent almost from the beginning.

The penetrating power of a projectile depends upon the hardness of its point and conical section up to its full diame-

ter. From that point on there should be a gradual decrease of hardness towards the opposite end, so that the shell may penetrate armour without injury to the pointed part of the shell,



VERTICAL SECTION OF GAS FURNACE.

while its body may remain sufficiently tough to prevent its splintering before it has penetrated armour plate to a sufficient depth.

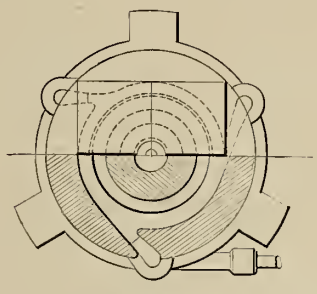
To secure hardness of the point and conical part of the shell it must be heated with great care. The point must be especially well guarded against excessive temperature; and the furnace must be so arranged that the heat can be distributed with perfect uniformity, or varied, and drawn to either one or the other end of the shell, at the will of the operator.

In the experimental plant in question the fuel used is naphtha gas, made by a special gas machine, and the gas is supplied by a pressure blower, both of the writer's design. The gas and air are delivered to a vertical furnace consisting of a fire-clay cylinder inclosed by iron bands, and the mixture of gas and air, properly proportioned, under a pressure of one pound to the square inch, is injected through three tuyeres which enter tangentially.

The flame thus does not impinge upon the body of the shell, but whirls around it with great rapidity. The distribution of the heat is effected by forcing the products of combustion to escape either from the top or the bottom through vent holes provided with fire brick slides, by means of which latter the vents can be either partially or completely closed or opened.

If the vent slide on top is open and the bottom slide closed, the heat will be drawn upwards. If, on the contrary, the furnace is closed on top, and the lower vent slide is open, the heat will be drawn downwards. The adjustment of the two slides in proper proportion will compel the distribution of the heat in any way desired. As the tendency of the heat is upwards, only a very small opening is required on top, and a larger one at the bottom, to force an even distribution of the heat; and if the lower portion is to be heated up in preference to the upper portion, the outlet on top should be closed altogether or only a very slight vent left there. A little practice in handling the vent slides enables the operator to vary the vertical distribution of the heat with considerable nicety.

For the protection of the point and conical section of the shell, a conical



CROSS SECTION.

recess is provided in the bottom of the furnace, which surrounds the point and as much of the conical portion as should be protected from direct heat.

DIPPING THE PROJECTILE INTO THE OIL BATH.

so that the extreme point is heated through conduction only.

The furnace is lighted by removing the plug shown at the side. This plug is replaced when the gas and air supply has been properly adjusted by two valves, one for gas and one for air, and by means of which the atmosphere in the furnace is charged with a slight surplus of gas to prevent oxidation.

The heating up of the shell can be observed through the lighting hole and also through the upper vent hole, and when the distribution of the heat has once been perfected by ascertaining the proper position of the top and bottom vent slides, the conditions for applying the heat to the shell are established, and the lighting hole affords a sufficient view of the shell to determine the proper time of its removal from the furnace.

After being properly heated, the shell is drawn out of the furnace and quickly transferred to the oil bath at the left by means of an overhead trolley. The manipulation of the shell in the bath is such that its square end will be still hot when the point is already chilled.

The plant has demonstrated anew that gas furnaces are advisable for obtaining the highest possible efficiency in the use of heat for mechanical purposes, and that heating operations can be performed with gas, which it is practically impossible to secure by the use of either solid or liquid fuel.

Naphtha gas especially lends itself to such purposes because of the purity of the heat derived from it, which, in all processes of metallurgy, is of the greatest importance. The cost of heating a 10-inch shell is covered by 2½ gallons of naphtha, costing 6 cents a gallon, and the heating is accomplished in one

hour, so that the proper heating of such a shell for hardening would cost 15 cents, exclusive of the cost of the power required to generate the gas and supply the blast, which is inconsiderable.

The heating of such a shell could be accomplished in half the time, if it were not necessary to give the heat time to penetrate every part thoroughly. To do the work properly a "soaking heat" is necessary, of exactly the right degree for the particular steel used.

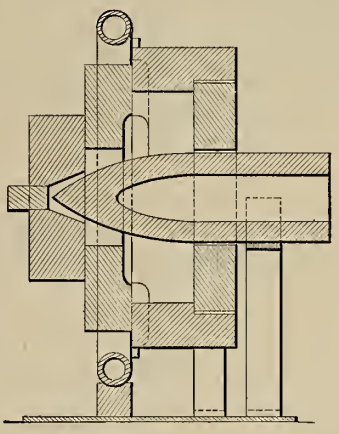
It would not do, for example, to heat a shell for hardening to a welding heat, since the outside of the shell would then become overheated before the heat had time to penetrate through the body of the metal. It would also be injurious to the quality of the steel, which would become brittle and liable to be shattered by the first impact, instead of combining toughness and hardness, as it should.

In coal-heated furnaces, great care and skill are required to properly handle a shell. The control of the temperature is exceedingly difficult, and depends altogether upon the skill and judgment of the operator. In a gas furnace the proper conditions, being once ascertained, can be reproduced with perfect accuracy, and the work turned out at all times under exactly the same conditions. The labour cost of doing the work is greatly diminished, and a man once trained in handling a gas furnace, will habitually do the right thing without constant supervision.

Another method for hardening projectiles has been recently tried and is an experimental success, but not yet in practical operation. It is to harden only a given cross section of a shell while the other parts are left soft, or only mildly tempered. This is done by exposing only the desired section to the heating process in a horizontal furnace constructed in a manner similar to the one described, the top and bottom of the old furnace now forming the sides, which are brought together sufficiently to form a heating space of any desired width.

The shell is inserted through central holes in these sides, of the diameter of the shell, the point being protected by a recessed cover applied from the outside, so that when the shell is inserted it projects out of the furnace with both ends, which are heated only by conductivity from the section exposed to direct heat in the heating space inclosed by the two sides. This furnace will enable the operator to more closely confine the heating process to a definite section of the shell.

The width of the heating space between the vertical walls of the furnace is determined by the exact width of the section to be hardened. If the theory upon which this furnace is designed is



FURNACE FOR LOCAL HEATING OF SHELLS.

correct, this device offers every needed facility for thoroughly hardening any section of the shell, while leaving especially the square end of it practically unaffected by the hardening of any other part of the shell. The advantage from the application of this newer method would be that after removal from the furnace the whole projectile can be submerged in a cooling bath without requiring any further manipulation, such as is necessary when the whole of the shell has been heated, as in the furnace first described.

RAISING SUNKEN VESSELS.

By Captain James Bell, Assoc. I. N. A.

IN the whole range of mechanical science there is hardly anything which has received less attention from engineers than the salvage of sunken vessels, and in consequence this has remained almost stationary over a long period, while every other branch connected with shipping has advanced with giant strides; at the same time there is no subject which has attracted more visionaries and dreamers.

In a paper presented by the writer some time ago before the British Association for the Advancement of Science, it was pointed out that whenever a large vessel is sunk, as in the cases of the *Grosser Kurfürst* and the *Victoria*, the newspapers are inundated with all kinds of wild schemes for the easy salvage of the vessels. It is of no consequence to these would-be salvors what the weight of the vessel might be, or the depth of the water which covers her, or whether the position may be an exposed one, and subject to strong tides or currents, —they all have plans or wildcat schemes by which the vessels can be easily raised.

In the case of the *Victoria*, sunk in 70 fathoms of water, it was, for example, seriously suggested to freeze, by chemical means, the water inside of her, and in the case of the *Vanguard* it was also proposed, among many other suggestions, to lift her by enveloping her in a huge canvas sheet, and pumping air inside of the vessel, thereby expelling the water and raising her to the surface. This plan, with illustrations, was published in one of the illustrated papers.

Wreck raising may be classed under two heads, viz., theoretical and practical. By theoretical is meant every plan that has been suggested or tried for that purpose, which, while it may have been scientifically correct in principle, has been found, in practice, to be either a total or a partial failure.

It may be interesting to note some of these. First, the plan of lifting with air bags placed inside the sunken vessel has been successful with a few small vessels, the *Prince Consort* paddle-steamer of 607 tons gross, sunk at Aberdeen, being the largest. The other vessels lifted by these means, at various times and places, have not exceeded 200 tons, and in very many cases there has been a complete failure with this system, as, for instance, with the paddle-steamer *Edith*, sunk in Holyhead Harbour, and the paddle-steamer *Brother Jonathan*, sunk in the River Mersey, and which, after many costly experiments, had to be lifted by means of pontoons or camels.

The air-bag system would be an excellent one practically if all vessels were empty or in ballast when they foundered in divable water, and the decks were built to withstand the strain necessary, and there were no projections, such as bolts, beams, etc., or frictional movements such as are set up by tide or currents, causing fatal injury to the air-bags, to say nothing of the rapid deterioration of plant of this description.

Another plan which has been attempted is to use cylindrical pontoons, constructed for the purpose, sinking them to the bottom alongside of the sunken vessel, and, having attached the pontoons with the aid of divers by chains or wires passing round the hull, giving buoyancy to the pontoons by pumping out the water. This plan

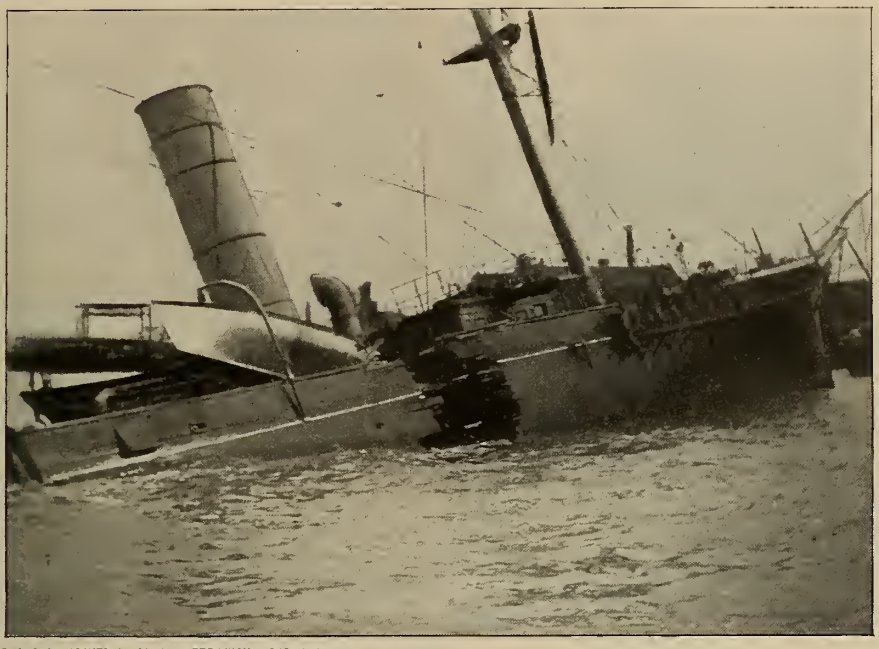


PHOTO BY NOAKES & NORMAN, GREENWICH, LONDON, S. E.

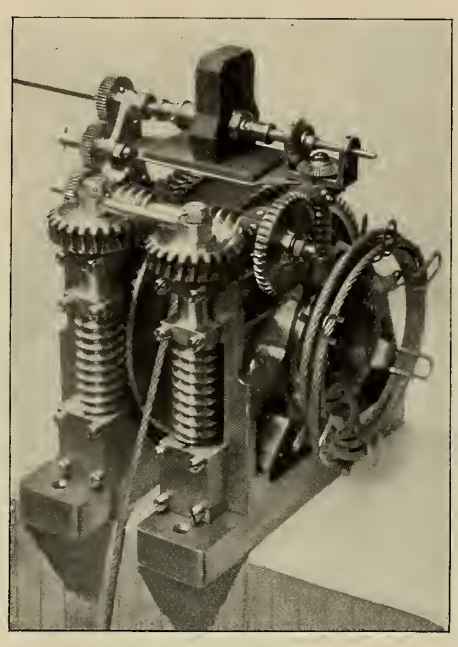
A COLLISION GASH.

would be simple and perfect if it were not that it is utterly impossible for divers to perform a tithe of the work that this method imposes on them.

The only methods which have been found practicable, and of which there are only two, are pumping, and stanking and pumping, which may really be called the one plan, as pumps are the main factors; and lifting by means of wire ropes and camels. The first of these plans can be, and has been, very successfully applied. The practice is, in case of a sunken vessel with no great depth of water on her decks, for divers to carefully shore up the decks with stout timber so that they will withstand the pressure of water from above when the water is pumped from under them. All hatches and deck openings have to be carefully covered with strong canvas and planking, and holes are cut in the covers just large enough to allow suction pipes to pass into the ship, and smaller pipes to admit air; when all is ready the water is pumped out by means of pumps on vessels moored above the wreck. If everything holds good, the vessel comes up; but great care is required to prevent her capsizing when she begins to lift.

Should the depth of water on a vessel's deck be considered too deep for this method, the ship has to be stanked, or raised upon—that is to say, balks of timber have to be bolted or secured to her waterways; thick planks have to be fastened to the balks, so that they come above water, and then they are decked across, and the whole is made watertight with canvas or oakum. The steam pumps are put on the platforms (it would not do to have vessels alongside for fear of damaging the structure), the water is pumped out, and, as the ship lifts, she is pulled into shallower water. When her main deck comes above water the structure is removed, the pumps are placed on her main deck, and the vessel is pumped out. This is the way in which several large steamers were raised, and it may be said to be the only practicable way in which very large steamers could be saved.

Of course, it will be seen that this is a costly, risky, and tedious method,



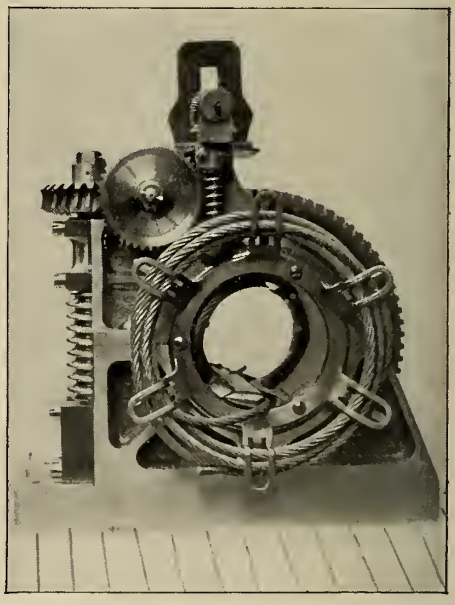
A WRECK-RAISING CRANE.

and, though it is the only way that has been successful in raising very large submerged steamers, it is not at all necessary in the case of the vast majority of steamers or of sailing vessels, whatever size the latter may be, as most vessels of, say, up to three or four thousand tons weight in water can be more cheaply and expeditiously raised by means of wire ropes and camels than by any other method, and that without the removal of any of their cargoes, with few exceptions, such as iron, tin, and heavy machinery. The removal of the cargo in the other plans is nearly always necessary, and, of course, very expensive.

The plan of lifting with camels entails little or no element of chance, and the only difficulty in the process is that of getting the rope under the vessel. It will be readily understood that the operation is the same in small as in large vessels, except that more ropes, and of a larger size, are required. Much of the property which is, at present, regarded as totally lost might be recovered, could the cost of salvage be reduced and the means of salvage be made more available, more economical, and more certain. Abundant instances could be given of valuable vessels abandoned as total losses, on the ground of inadequate appliances. Besides that, there is the great necessity in many cases of removing sunken wrecks which are obstructions to harbours, fairways, etc., and which, if they are of any size, are generally disposed of by the barbarous use of explosives.

Every vessel, however, large and small, which has been sunk in the Thames during about the last 15 years has been lifted by pontoons. These pontoons are secured by wire hawsers to the sunken vessel at low water, and as the tide flows, the hawser takes the weight of the vessel, the pontoons sink to their displacement, and the cortege is towed to the most suitable place for beaching. The whole efficiency of the plant of the Thames Conservancy is derived from the action of the tides, and would, therefore, be lacking where there is no rise or fall of the water.

Something different from this plan has been long wanted among salvage engineers, especially where the tidal range is small or nearly absent, as on some parts of the British coasts, in the Mediterranean, on the Southeastern



ANOTHER VIEW, SHOWING INTERNAL ROPE GUIDE.

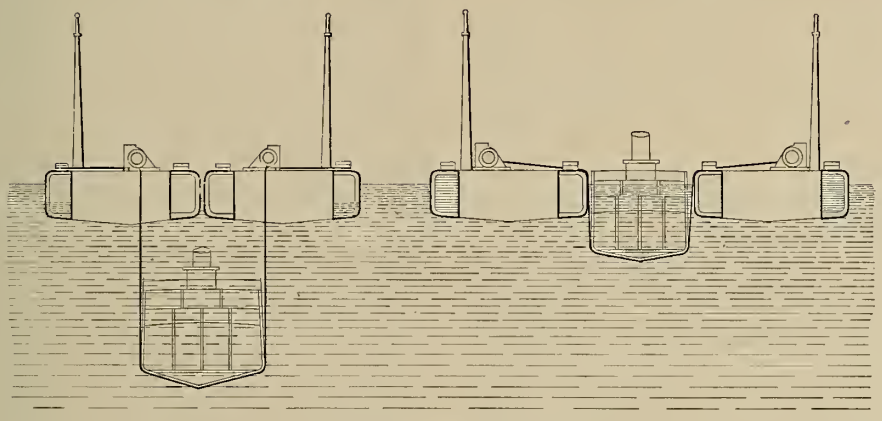
coasts of the United States, in the West Indies, and on the great lakes of the United States and Canada.

To substitute the power of a rising adequate tidal range, it was necessary to design a mechanical power equal to the power of the tide on the displacement of the pontoons employed, and a power, at the same time, that would be completely under the control of the salvage engineer. The great improvements in the manufacture of wire hawsers during recent years has made it feasible to lift much heavier weights, by means of pontoons, than was at all possible when chains were used. One of the great difficulties was to devise a plan, whereby a huge wire hawser, say, ten to eleven inches in circumference, could be grasped at any given point or part, without injury to the rope while carrying its full load, even to the breaking point. The cranes shown in the illustrations on the opposite page can do this. They will also heave up any weight that the rope can carry, and exactly register the weight carried by the hawser.

The weights are hove in steadily, and in case of necessity can be lowered much more quickly than they are lifted. Each crane has a revolution counter, and the indications of the weights and revolutions are electrically reproduced at a common centre, say a bridge house on any one of the camels, thus enabling the salvage engineer to have full control of the lifting power at his command, and a perfect knowledge of the strain on each and all of the wire hawsers.

On the base-plate of each crane are two frames supporting the ends of the hollow winding barrel, at one end of which is a reel by which the unused portion of the rope is carried. The barrel is worked by a series of worms and worm wheels and driven by gear wheels from the motor shaft, the latter being revolved by suitable power, either electricity, or steam, or some other form.

When starting lifting, little or none of the rope will be on the barrel; while the part connected to the body to be moved would be tight, the remainder of the rope would be passed to the reel by way of a hole of gradual curvature, and over two grooved internal guides, by which, when tension comes upon the ropes, friction is created, and assistance to the holding afforded. Between the guides and the reel, there is a compressor, by which the actual holding and making fast of the rope is effected. Owing to the friction of the internal curvature guides just mentioned, the pressure required in the compressor is very little. The lead of the rope from the barrel to the reel is nowhere bent or turned at such an angle as to injure the rope; that is, the turns are easy and gentle, and the rope cannot pos-



PONTOONS FOR WRECK RAISING.

sibly be damaged by gripping in the machine.

It will be seen that, as the barrel revolves, the unused portion of the rope revolves with it. The reason for adopting worms and worm wheels in preference to other gearing, is because of the steady motion obtained, by which all surging on the ropes is avoided, and in case of breakdown in the driving power, the machine cannot run back.

The worm gear allows also of a more compact form of machine, power for power, with a minimum number of parts, and small liability to stoppages through a breakdown. As the breaking strain of the cranes is calculated at about 800 tons each, and the heaviest load to be lifted about 150 tons each, it will be seen there is such a large margin of safety that the possibility of a breakdown may be altogether ignored.

For such cranes it was necessary to devise suitable camels, of which the following is a description:—They are a series of pontoons (four are shown in this instance), each 125 feet long by 49 feet beam (this measurement having been fixed upon to enable the pontoon to enter harbours with an entrance width so small as 50 feet) and 16 feet depth at the centre, with a slight camber to the sides. Each camel is divided into six transverse compartments, the four central ones being used as engine, pump, and boiler rooms, living rooms, and store rooms, and the fore and aft compartments being filled or emptied to raise or lower either end. Between these compartments are five transverse wells, or openings, running athwart vessel to within nine feet of either side, over which are placed, so as to move up and down the length of the well as required, the winches for heaving on the lifting ropes. By means of this construction, when the vessel to be raised is large and lying at a considerable depth, the ropes can be taken up from her to and through the camels so as to get a direct pull or strain on them; and no matter what the width of the sunken vessel, the same set of camels can always be used, all that is required being to arrange the winches so as to get a direct and vertical pull. The arrangement of the winches over the wells at the same time permits a sufficient distance being maintained between the sides of the camels on each side of the wreck, so as to prevent their bumping against each other.

When the vessel to be lifted does not exceed half the displacement of the camels, or is not completely submerged, so that the masts would be in the way of its being raised by the direct pull through the wells as above, the ropes are carried from the winches over suitable rollers on the inner sides of the camels, the sides being specially strengthened at those points to take the weight of the pull. To provide against the tipping of the camels when the pull is made in this manner, or from a point not quite in the centre of the camel, a longitudinal bulkhead runs along either side of the camels, with transverse bulkheads between the ends of the wells and the sides of the camels, forming the side chambers into a number of compartments, which can be filled or emptied, as required, by pumps through valves in the hollow box, keelsons running throughout the camel, so as to keep it balanced. These valves are worked from the interior of the hollow bollards. The winches are also moved outwards from the left so as to aid in the balancing.

All the water compartments being right around the camel, and being subdivided into a large number of chambers, the pontoon is practically unsinkand is so constructed that it can be towed anywhere in any kind of weather.

The limit of the weight of any ship to be lifted is governed only by the amount of the displacement of the camels, and the number of cranes employed: but a plant capable of lifting four to five thousand tons would be fully sufficient for all ordinary requirements.

MISCELLANEOUS TORPEDO VESSELS.

By Lieutenant R. C. Smith, U. S. N.

THE various types of torpedo vessels which have sprung into existence since the early days of torpedo warfare were made the subject of brief review by Lieutenant Smith in a paper presented several months ago to the United States Naval Institute. This has been reprinted in the following pages as the best existing exposé of the status of these boats at the present day and of the kind of service which they may be expected to successfully perform.—THE EDITOR.

The building of torpedo vessels other than fast launches and torpedo-boats was preceded by one or two tentative types before their lines were definitely determined. Thus in 1874 the British launched the *Vesuvius*, which was called a torpedo ship. She was built of iron, and was 90 feet long, with a displacement of 245 tons and a speed of 9.7 knots. Her armament was four submerged tubes for Whitehead torpedoes. With twin screws and coke for fuel, and the products of combustion arranged to be discharged from side holes in horizontal flues, she was intended to be handy, smokeless and noiseless. Her speed was deficient.

The Italian *Pietro Micca* dates from 1876. She was built of iron, was about 200 feet long and of 550 tons displacement. There was an armour deck 10 inches below the water-line, with sloping sides, heavily plated with steel and iron. The intended speed was 18 knots, but she did not realise over 14. She was fitted with two submerged tubes and carried ten torpedoes, besides two machine guns. She was filled with machinery, and had four boilers.

The Swedes built the *Ran* in 1877, subsequently called the *Drott*. She was a twin screw iron ship of 175 feet and 630 tons, and had a speed of 13 knots. The armament was three torpedo tubes, one submerged, and four rapid-fire guns. She was fitted also for the Harvey torpedo.

Rather a remarkable vessel of her day was the Danish armoured torpedo ship *Tordenskjold*, 1880. She was a steel, twin-screw, turtle-shaped vessel, with a 3.7-inch armoured deck and an 8-inch armoured barbette. Her length was 222 feet, displacement 2400 tons, speed 14 knots. She had a cellular double bottom surmounted by an inner ship of forty cork-filled compartments. Above this were the armament, torpedoes and crew space. There were four torpedo tubes, over-water, five Krupp guns of from 12 to 30 centimeters calibre, and eight machine guns. She carried, in addition, two torpedo-boats.

A somewhat similar vessel, guns excepted, was the English torpedo ram *Polyphemus*, 1881. She was a twin-screw, steel, turtle-back vessel of 240 feet and 2640 tons. Her best speed was 18 knots. The armament was five submerged torpedo tubes, forty torpedoes, six 6-pounders and two machine guns. The steel deck was two or three inches thick. She was fitted with bow and stern rudders, and could take aboard water ballast to sink her to just awash.

The above vessels were not reproduced, though there are possibilities in some of them. A fast armoured torpedo ram may yet be in favour, as it is not difficult to imagine cases in which such a vessel, acting singly or with the fleet, would give more than a good account of herself.

Two other types of torpedo craft may be briefly discussed here, and the way will then be clear for the cruisers, gunboats and destroyers. These are the torpedo depot ship and the German division boat.

Of the first, the *Hecla* was the pro-

totype,—a British merchant steamer taken into the service and fitted for the purpose. She was followed by several others. The functions of the depot ship were to carry spare torpedoes and stores and a large number of second-class boats to hoist out when they should be of use. They were fitted with large repair shops, and could carry relief crews for the boats as well as medical officers and stores.

The division boat acts as the flagship of a division of torpedo-boats. It carries also spare torpedoes and stores, relief crews, medical supplies, and is fitted with repair shops, all naturally to a more limited extent than in the case of the depot ships. It can be used as a scout for its division, and to a certain extent as a torpedo-boat destroyer. While these boats are about the size of the destroyers, they have not their lines or build, and the earlier ones did not have the speed. In one important feature they are very different. Their draught is 10 to 12 feet, nearly double that of the destroyers, and they are, therefore, incapable of following torpedo-boats into shoal water.

It is doubtful if either of these types can be of much value in the future. It has become apparent that the day of the second-class boat is perhaps past, and that first-class boats are at their best when operating from shore bases. The independent duties of the division boats can be performed by the regular scouts or by the destroyers. Their stores and supplies will not be required by the torpedo-boats, for they will seek their own bases to renew their supplies and rest their crews; and the destroyers are capable of taking care of themselves equally with the division boats.

The utility of the torpedo depot ship disappears by the same reasoning. But it may be desirable to fit up a large vessel as a floating repair shop for the whole fleet, and send her where she is most needed.

Torpedo Cruisers.

The immediate predecessors of the torpedo cruisers seem to have been the fast despatch vessels which were in vogue ten to twenty years ago. The *Zieten* was a torpedo and despatch vessel built by the Thames Iron Works for Germany in 1876. She was a twin-screw iron vessel of about 200 feet and 1000 tons, with a long, low hull, and bow and stern torpedo tubes six feet under water. The designed speed was 16 knots. She carried lately 10 machine guns.

The *Staffeta*, built by the Italians at the same time, was 253 feet long and displaced 1388 tons. Her speed was 14 knots. She had one torpedo tube, four 12-centimeter guns and a number of smaller ones.

The German *Blitz* and *Pfeil*, 1882, were much the same. They were twin-screw steel vessels of 246 feet and 1382 tons. Their maximum speed was 16.3 knots. Their armament was one submerged tube, besides rapid-fire and machine guns.

The *Alacrity* and *Surprise*, built by the Palmers for the British government in 1885, were purely despatch vessels, but they gave by their lightness and speed a suggestion of possible torpedo use. They were twin-screw steel vessels of 250 feet and 1600 to 1700 tons. They made upwards of 17 knots with forced draught. The *Alacrity* was armed with ten 6-pounders and two machine guns. It will be seen how opinion is reverting to this style of armament for vessels of this type to the exclusion of torpedoes.

Next came the British *Curlew* and *Landrail*, in 1885-'6. They came very near the eventual torpedo cruiser, but they were too small and too slow. They were twin-screw steel vessels of 195 feet and 950 tons, with a speed of 14½ knots. Their armament was a number of 5-inch and 6-inch breech-loaders, besides rapid-fire and machine guns, and three torpedo tubes. Thus, it is seen, the torpedo is beginning to assume prominence.

At the same time the Armstrongs were building the *Leopard* and *Panther* for Austria. They were 224 feet long, displaced 1530 tons, and had a speed of 18½ knots. They carried four torpedo tubes, in addition to a numerous

gun armament. They were built with a high poop and forecastle for weatherly considerations and were much subdivided.

In the British *Scout* and *Fearless*, 1885-'6, the typical torpedo cruiser was reached. Subsequent steps have been retrogressive, at least as regards the torpedo features. They were about the size of the *Leopard*, but had scarcely more than half the horse-power. They were loaded down with both guns and torpedoes. They were 220 feet long, displaced 1580 tons, and steamed 16.7 knots. They carried originally eleven torpedo tubes, one of which, in the bow, was submerged. Four have since been removed. The gun armament consisted of four 5-inch and eleven rapid-fire and machine guns. The type was intended to keep the sea in all weathers and afford comfort to the crew. They were designed as a result of the shortcomings of torpedo-boats proper, and were referred to in the prints of the day as sea-going torpedo-boats.

The French contemporaries of these vessels were the *Condor* and her class, the *Epervier*, *Faucon* and *Vautour*. Their design really preceded the British ones, but they were longer in building. They were 217 feet long, displaced 1240 tons and made nearly 18 knots. Their armament was five torpedo tubes and five 10-centimeter guns, besides rapid-fire and machine guns. The upper deck was turtle backed the whole length; there was a 1½-inch steel deck, a splinter deck, a double bottom, and a cellular water-line belt. They had compound engines and four locomotive boilers.

A number of other vessels of this type followed in different countries, but it is not necessary to describe them here. The British *Archer*, a slightly enlarged and modified *Scout*, and the American copy, the *Yorktown*, exemplified the type in the essential features. The German *Greif* (1886) and the Italian *Coatit* (1896) are the fastest of any of them, having been designed for 23 knots.

This class of vessels, as torpedo cruisers proper, have not proved a success. They were intended to chase and destroy torpedo boats, as well as to engage large ships with their torpedoes. They were loaded with guns, men, torpedoes and machinery. The fastest of them can catch torpedo boats proper in deep water and in a sea way, but they cannot follow them into shoal water. It is hard to understand in what way they were intended to use their torpedoes. They are too large to make a surprise attack. They have guns heavy enough to engage much larger and heavier vessels, but they would not dare to come near enough to use them. Stripped of their heavy guns and torpedoes, they would make very efficient scouts, especially the later and faster ones. They would carry a very numerous armament of medium-weight and light rapid-fire guns. In France this rearmament is already taking place, and markedly in the class of torpedo gunboats.

Torpedo Gunboats.

In the early days of the torpedo, the generic title of vessels expressly fitted for its use was torpedo vessel or torpedo ship. As the type developed, differences began to appear. Several comparatively slow vessels of various sizes retained their original name. The larger ones of moderate speed were known eventually as torpedo cruisers, with an intermediate stage of despatch vessels, as has been shown; and the smaller ones came to be called torpedo catchers, and finally torpedo gunboats.

The eventual French names of the various types, in order of size, may be given here as follows:—Croiseurs-torpilleurs, avisos-torpilleurs, éclaireurs-torpilleurs, torpilleurs de haute mer, torpilleurs - garde - côtes, torpilleurs-vedettes.

The Austrians were the first in the field with gunboats by several years. Their *Spalato* and *Zara*, dating from 1879, were twin-screw steel vessels of 180 feet and 840 tons, with a speed of 14 knots. Their armament was a number of small calibre breech-loaders and machine guns, and two torpedo tubes. They had a protective deck and high-

speed compound engines supplied by locomotive boilers. In these regards they marked a decided advance in construction, but the speed was a disappointment.

The *Sebenico* (1882) and the *Lussin* (1883) were of the same displacement, but were slightly longer. The speed was the same. The *Lussin* had two 6-inch guns, besides smaller ones, and two torpedo tubes.

The French *Bombe* class (1885-'6) were, however, the pioneers of the typical torpedo gunboat. The duties of this type may be summarised as follows from the Annual of the Office of Naval Intelligence, 1891:—The tactical use of the torpedo gunboat is to destroy torpedo-boats before the latter can reach the ironclads of the fleet; to cruise inside the blockading fleet and to give warning of the enemy's movements; cruising with the fleet to act as scouts, engage similar vessels, support torpedo-boat flotillas; to attack the enemy's squadron at night or force a blockade; and to undertake the duties of a high-sea torpedo-boat.

The *Bombe* class were twin-screw vessels lightly built of steel, 197 feet in length and of 395 tons displacement. Their speed was 18 knots, which was made with 2000 indicated horse-power. They were fitted with a water-line belt of cellulose. The sides were turtle-backed. The original boilers were of the locomotive type. They have been changed in the *Bombe* for the D'Allest. Nine water-tight compartments were fitted. The complement was 63 officers and men. The armament was two torpedo tubes in the bow and seven rapid-fire and machine guns. The vessels were handy, but the construction proved too light. They rolled a great deal, and were wet and uncomfortable.

The British *Rattlesnake* dates from 1886. She was built of steel with a half poop and forecastle. The length was 200 feet, displacement 550 tons. She made 19½ knots on 2800 indicated horse-power. The armament was four torpedo tubes, one 4-inch breech-loader and six 3-pounders. There were four locomotive boilers. This type was adopted by the Board on Construction to obviate the difficulties due to wearing out of crews and constant breaking down of torpedo-boats. They were also intended to overhaul torpedo-boats in rough weather. Their light draught would ordinarily safeguard them against torpedoes.

Subsequent British types have been merely developments of the *Rattlesnake*.

The Italians entered the field with the *Folgore* and *Saetta*, 1886-'7. They were 186 feet long, displaced 377 tons, and made 20 knots on 2000 horse-power. They had four torpedo tubes and seven rapid-fire and machine guns.

The first four of the *Tripoli* class followed that year and the next. They were noted for their triple screws. They were much larger, reaching 845 tons and 230 feet. Their armament was five torpedo tubes, one 4.7-inch and seven other rapid-fire guns. The speed was 20 knots on 3600 horse-power. The class has been subsequently reproduced to the present time, except as to the triple screws, which were not repeated. The earlier vessels were too light and vibrated excessively. This has been corrected in later ones.

In 1886-'7 Messrs. J. & G. Thomson built the *Destructor* for Spain. She was 193 feet long and displaced 458 tons. She made from 20 to 23 knots on 3800 horse-power, according to the load. She had four cylindrical boilers and 39 water-tight compartments, with each boiler and engine in a separate compartment. She had complete coal protection and a curved 1¼-inch steel bulkhead forward. She was cut away at the ends for manœuvring, and had a bow rudder. The masts were hinged to lower. The armament was five torpedo tubes, one 9-centimeter gun, and six rapid-fire and machine guns. She, like the *Wiborg*, was built for head-on attack.

It is not necessary to go farther with the descriptions. The class as such has never proved satisfactory. The size has been continually increased in the endeavour to make the vessels fast, habitable and seaworthy, until the distinctive torpedo features have practi-

cally disappeared. They have never been equal to catching the best of the torpedo-boats—a duty now relegated to the destroyers. Scouting is therefore all that is left to them. By omitting their torpedoes, other qualities can be improved, such as speed, coal endurance, gun armament and ammunition.

The French have in great measure taken this view, and the order has been given to remove the torpedoes from all the class, a work now actually in progress. The boats, however, are still to be used as catchers. All of the intermediate types between cruisers and torpedo-boats are classed as contre-torpilleurs in the latest published lists. The more recent and fastest of them, with a numerous armament of light rapid-fire guns, should, in addition, make very efficient despatch vessels and scouts.

Torpedo-boat Destroyers.

The next type of vessel to be considered is the torpedo-boat destroyer. The genesis of the type has been fairly well indicated in what precedes. The gunboats had been getting bigger and bigger, but had never been able to accomplish the object of their design, *i. e.*, to catch torpedo-boats. It was decided, therefore, to build a big torpedo-boat, with plenty of engine power, and to arm her with a large number of light guns. This departure has resulted very satisfactorily. Although the destroyer was designed primarily to accompany the fleet and guard it from torpedo-boats, it was soon seen that as a high-sea torpedo-boat itself, with a moderate armament of both guns and torpedoes, it was the logical solution of the very difficult requirements of the case. The name has been retained to designate the type, but it now only partially indicates the use to which such vessels may be put. High-sea torpedo-boat would perhaps be a better designation; for it is a very good rule that any boat should have a sufficient gun armament, in addition to her torpedoes, to engage vessels of her own size and to destroy any smaller ones, which would, in fact, constitute her a destroyer.

The *Havock*, the first of the type, was built by Yarrow in 1893. She was 180 feet long, displaced 220 tons, and steamed 26.8 knots on 3500 indicated horse-power. She had three torpedo tubes, one in the bow and two on a turntable on deck. The gun armament was one 12-pounder on the conning tower and three 6-pounders distributed on deck. The lines of the vessel had all the characteristics of the torpedo-boat, such as light draught, full body, sharp bow and full stern, all on an enlarged scale. Forward was a high turtle-back extending to the after side of the conning tower. She was divided transversely by thirteen bulkheads, and there were twenty water-tight compartments in all. The conning tower was of ½-inch steel plates. The *Havock's* boilers were of the locomotive type, though her sister-boat, the *Hornet*, had tubulous boilers.

It is not intended to describe all of these boats. The size has increased to 210 feet and 300 tons, and the horse-power to 6000 or over, designed to give a speed of 30 to 32 knots. Some mention may be made of two or three of the most recent. The *Sokol* was built by Yarrow for Russia in 1895. Nickel steel was employed to lighten her construction. She is 190 feet long, of 240 tons displacement, and was guaranteed to make 29 knots on 4000 horse-power. She has triple expansion engines and Yarrow's straight-tube boilers. The armament is two single deck tubes for 16-inch torpedoes, one 12-pounder and three 6-pounders. On her official trial, with 30 tons load, she made 29.76 knots for three hours on 3700 horse-power with an expenditure of 2.1 pounds of coal per horse-power per hour. She made 30.28 on the measured mile with 4490 horse-power, the then fastest speed.

The *Desperate* has just been built by Thornycroft. She is 210 feet long and displaces 272 tons. She made 30½ knots on 5600 horse-power with a coal consumption of 2.49 pounds per horse-power. The load carried was 35 tons.

A departure has been made by Yarrow in four boats for the Argentine,

now about completed, of which the *Santa Fé* is the first. They are protected by ½-inch steel armour completely surrounding the engines and boilers. The speed is 26½ knots, which means a sacrifice of three knots or more as compared with the *Sokol*, a vessel of practically the same size by the same firm.

This question of armour for large torpedo-boats, while advocated by some authorities, is not generally regarded with favour. The thickness of the armour is scarcely sufficient to be of much protection in an attack on a battle-ship or large cruiser. Surprise is here the best defence; and if this is effected, armour will not be required. In an engagement with other boats, armour might be of service, but hardly at the sacrifice of speed. An important duty of these boats is to protect the fleet from torpedo-boats. Should they fail in this through insufficient speed, the armour would be worse than useless. Taken altogether, if there is any weight that can be spared after the requisite speed and coal endurance are secured, the best place to utilise it would seem to be in added guns and ammunition.

SOME BRITISH HIGH-SPEED ENGINES FOR ELECTRIC LIGHT AND POWER STATIONS.

By J. C. Peache.

IN the early days of the electric light there were already in the market two types of high-speed single-acting engines which had acquired some prominence in steam launch work and in other applications that called for compactness and high rotative speeds.

Mr. Brotherhood and Mr. Willans, the inventors, respectively, of these engines, were quick to enter the new field of work which the coming light was opening out, and apply their engines to the direct-coupled driving of the new dynamos.

An early example of a Willans combined set is shown in the illustration on page 342. In this engine the inertia of the reciprocating parts at the upper part of the stroke was cushioned by Mr. Mark Robinson's "air buffer," a device which still forms an essential part of the engines made by Messrs. Willans & Robinson, Limited, of Rugby. This particular engine, however, was of a type that has been superseded by the Willans central valve engine. It had three cranks set at angles of 120°, the pistons of one line forming also the valves for the line of pistons next to it, the ports from the end line stretching back to the pistons at the opposite end of the engine and thus completing the ring.

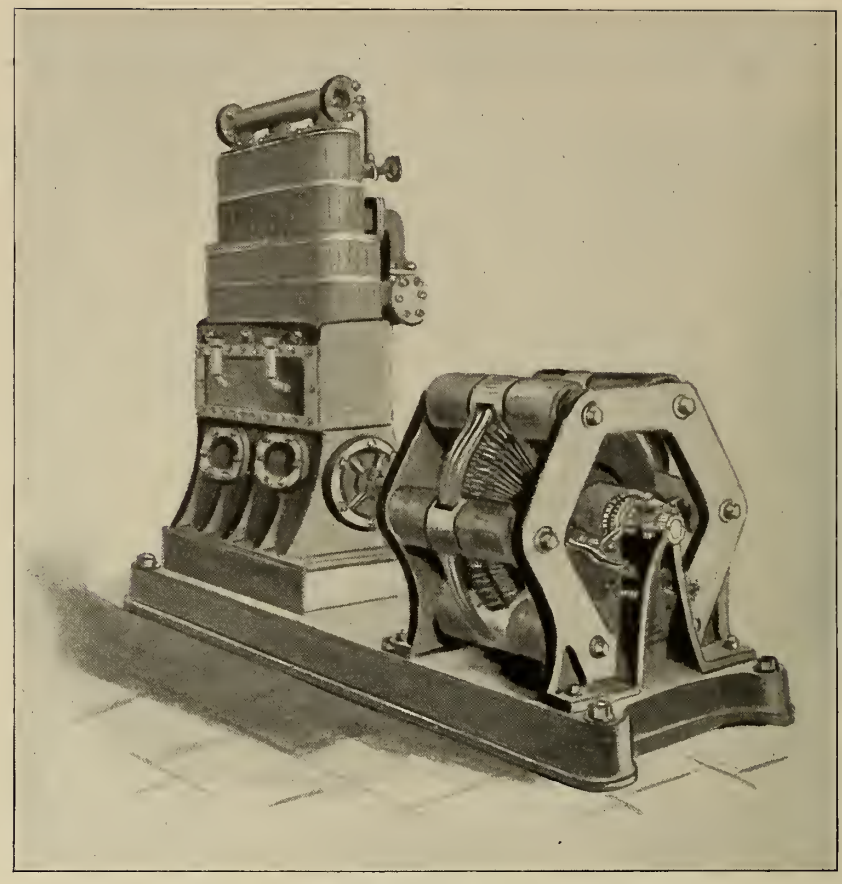
Besides the Brotherhood and Willans sets there were other early instances of direct coupling, notably with the Porter-Allen engine, in America; but with the exception of the two first-named none of these early attempts established themselves, and for many years belt or rope driving was the rule.

Direct coupling saves the power that would otherwise be absorbed by friction in the intermediate gear between engine and dynamo. In the case of a rope or belt drive this loss is seldom, if ever, less than 7 per cent. of the full power which it is capable of dealing with, and as this amount remains nearly constant whatever may be the power transmitted, it follows that the loss from this cause forms an increasing percentage of the output as the load is reduced.

In the early belt-driving plants the speeding up between engine and dynamo was effected through a countershaft and two belt drives, so that the absorption of power between engine and dynamo even at full power amounted to, at any rate, nearly 14 per cent., and at outputs of less than full load to even a larger percentage of the power applied.

The high-speed direct-coupled engine, therefore, started with a great economical advantage over its slow-running, belt-driving competitors, sufficient, indeed, to more than counterbalance the larger consumption of steam per I. H. P. which the early types of high-speed engines entailed.

Although the mechanical advantage of direct coupling was thus early demonstrated by the application of high speed engines to dynamo driving, it was not until the late Mr. Willans brought out his central-valve engine, in 1884, that the full economic advantage to be gained by direct coupling was made apparent. The first engine of the central-valve type was applied to the driving of a dynamo on board H. M. S. *Black Prince* in that year, and this was quickly followed by a batch of engines of 200 I. H. P. each for



AN EARLY TYPE OF WILLANS ENGINE AND DYNAMO.

a central electric lighting station in Vienna. These engines were identical in their main features with the present engines made by Messrs. Willans & Robinson, Limited, and exhibited the characteristics of high economy and efficiency which have since gained such a reputation for the engines built by that firm.

In America, the Westinghouse high-speed single-acting engine soon followed the Brotherhood and Willans engines, and took a prominent position in electric light work in that country.

Isolated cases of other types of engines direct-coupled to dynamos cropped up here and there, but belt-driving died hard. First the double drive and countershaft disappeared in favour of the single drive, but it is only within the last few years that on the European Continent and in America the balance of opinion has, following the course previously adopted in Great Britain, gone over to direct-coupled driving.

In Great Britain the bulk of the work is entrusted to high-speed engines and two-pole dynamos. On the Continent, inverted vertical engines of the marine type and multipolar dynamos are the representatives of direct-coupled driving. In America the honours are divided between engines of the marine inverted type and engines of the horizontal type, both coupled to multipolar dynamos.

Although dynamo rotative speeds

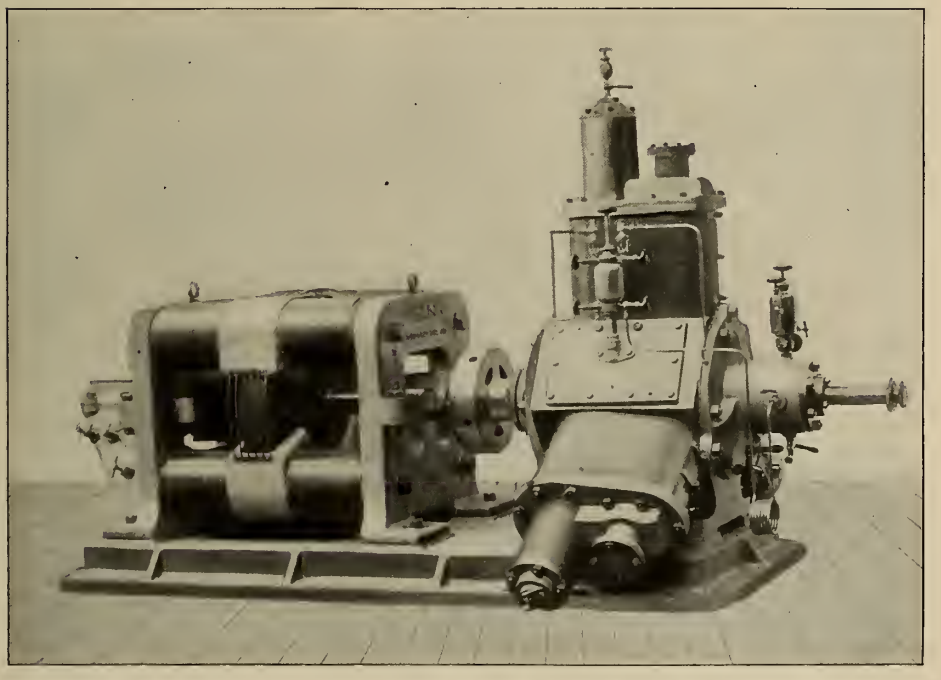
have been brought down to meet these latter types of engines, still the engines have been speeded up to meet the dynamo requirements until it becomes difficult to say where normal speed ends and high speed begins.

For the purpose of this article the term high-speed, as applied to revolutions per minute, may be defined as a speed of not less than 300 revolutions per minute for a power of 300 I. H. P., and corresponding speeds for engines of less or greater powers. This definition includes all engines that come within the ordinary acceptation of the term high-speed as applied to engines, and it is to the description of the limited number of examples of that particular class of engine that the scope of this paper is confined.

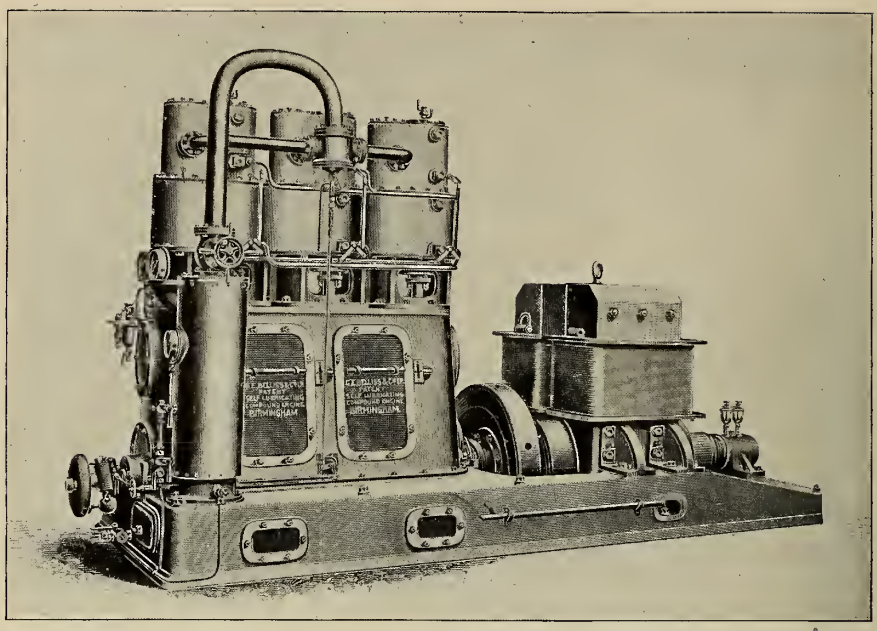
Before proceeding to describe some of the high-speed engines that are being used in electric central stations it will be well to call attention briefly to some of the conditions that this type of engine has to meet and to some of the limitations to which it is subject. The first problem is the control of the enormous inertia forces which arise in the reciprocating parts at high rotative speeds. In an engine with a 10-inch stroke, running at 375 revolutions per minute, the inertia of the main reciprocating parts at the ends of their stroke amounts to twenty times their weight, or allowing for the effect of the connecting rod length, say, to twenty-four times their weight at the top of the stroke and to seventeen times their weight at the bottom of the stroke.

In a high-speed tandem compound engine with a 10-inch stroke the weight of the main reciprocating parts would amount to about 1½ pounds per square inch of low-pressure piston, so that at the top of the stroke an inertia force equivalent to 36 pounds per square inch of low-pressure piston has to be overcome in stopping the main reciprocating parts and again starting them on the down stroke.

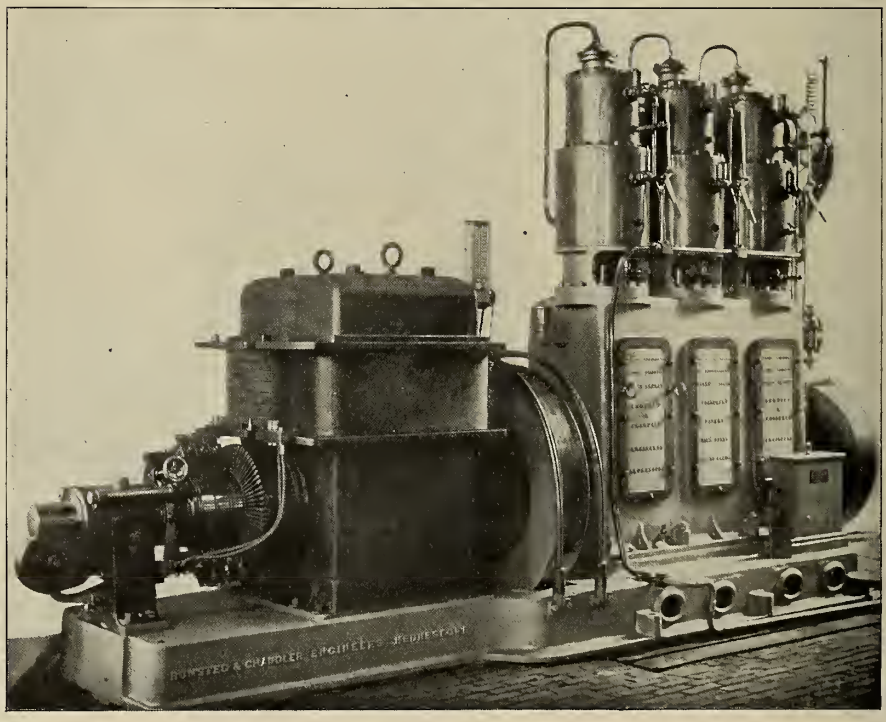
At the bottom of the stroke an inertia force equivalent to 25½ pounds per square inch of low pressure piston has



THREE-CYLINDER, SINGLE-ACTING ENGINE, BUILT BY PETER BROTHERHOOD, LONDON.



THREE-CRANK TANDEM COMPOUND ENGINE, BUILT BY MESSRS. G. E. BELLIS & CO., LTD., BIRMINGHAM.

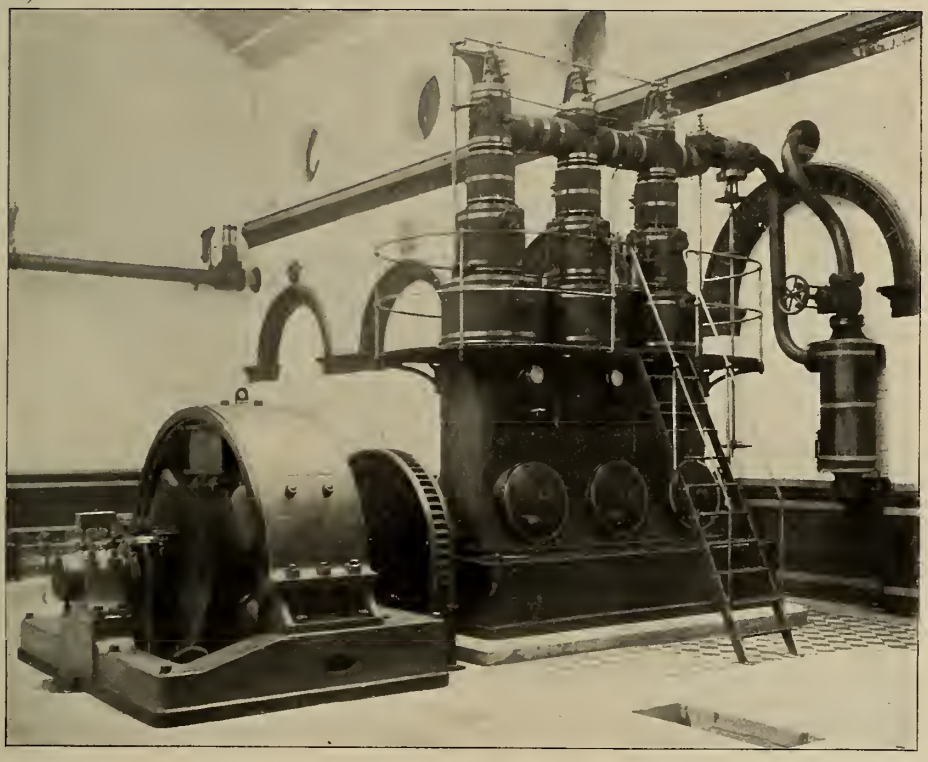


THREE-CRANK TANDEM-COMPOUND, SINGLE-ACTING ENGINE, BUILT BY MESSRS. BUMSTED & CHANDLER, HEDNESFORD.

to be similarly dealt with. The force of gravity assists the operation at the top of the stroke and adds to the force to be dealt with at the lower end of the stroke, so that the actual inertia forces to be controlled within the engine are modified to the equivalent of 34½ and 27 pounds per square inch of low-pressure piston at the upper and lower ends of the stroke, respectively.

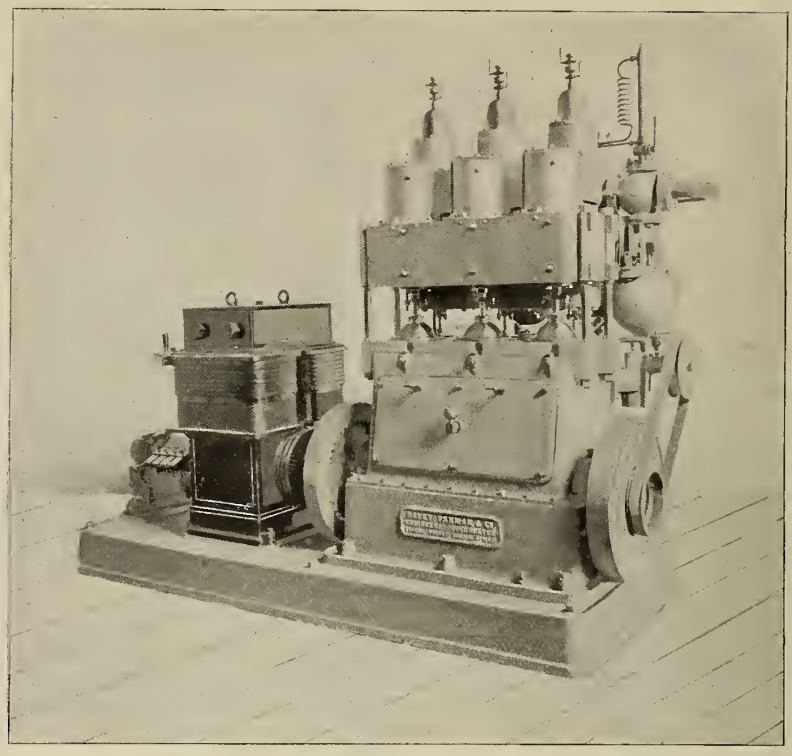
In the single-acting engines the upward inertia forces are balanced entirely of the Willans and other single-acting engines, and by its means, no matter how much the bearings may wear, or how long the engine may run without stopping, the journals and bearings will not part company or cause hammering. In a word, backlash is eliminated.

Messrs. G. E. Belliss & Co., Limited, of London, have boldly taken the line that they will have no wear in their engine bearings, and although the ordinary compression in the steam cylinders



TRIPLE EXPANSION WILLANS ENGINE 700 H. P. CONDENSING ENGINE AT THE BRADFORD ELECTRIC LIGHT STATION, BUILT BY MESSRS. WILLANS & ROBINSON, LTD., RUGBY.

in the cylinders,—in the Willans engine principally by an air cushion in a special cylinder provided for that purpose, and in other single-acting engines entirely by steam cushioning in the working cylinders. The pressures in the cylinders are always in excess of the upward inertia forces of the reciprocating parts, and therefore always maintain a downward pressure on the bearings. This constant thrust is the special feature to some degree helps in controlling the enormous inertia forces of the reciprocating parts at the ends of the stroke, yet the crankshaft and other bearings have to do the main part of the work of checking and reversing the motion of these quickly moving parts. The way in which Messrs. Belliss eliminate wear is by keeping the surfaces of journals and bearings separated by a film of oil supplied under pressure to each bear-



THE PEACHE SINGLE-ACTING ENGINE BUILT BY MESSRS. DAVEY, PAXMAN & CO., COLCHESTER.

ing. The prominent position which the Belliss engine holds in the electrical world and its beautifully quiet running have certainly justified the bold departure of the makers from ordinary practice, even if they have not indefinitely postponed the necessity of adjusting their brasses for wear. Other makers have adopted forced lubrication for high-speed double-acting engines, while Mr. Raworth, in his engine, relies on the normal action of the journals to draw in the necessary film of oil.

It has been contended by advocates of the normal-speed double-acting engine that since in the single-acting engine the pistons and journals have to cover double the ground for a given power, the rings and bearings must wear away faster, and that they must cause more loss by friction than is the case with a double-acting engine. It must be remembered, however, that for a slow-speed double-acting engine the moving parts, especially the fly wheel, all of which have to be borne by the cylinder and bearing surfaces, are far heavier than the corresponding parts in a high-speed single-acting engine. The balance of gain and loss is thus adjusted. In any case, it has been proved in practice that the high-speed single-acting engine is not inferior to the slow-speed double-acting engine in point of mechanical efficiency.

With the double-acting high-speed engine all the advantage of lightness of moving parts is gained without the extra ring travel and bearing friction of the single-acting engine. It is not surprising, therefore, that Messrs. Belliss should show, as they do, a high mechanical efficiency in their engine tests. In a trial made by Prof. Kennedy on a Belliss engine of 200 I. H. P. for the Sunderland Corporation electric supply

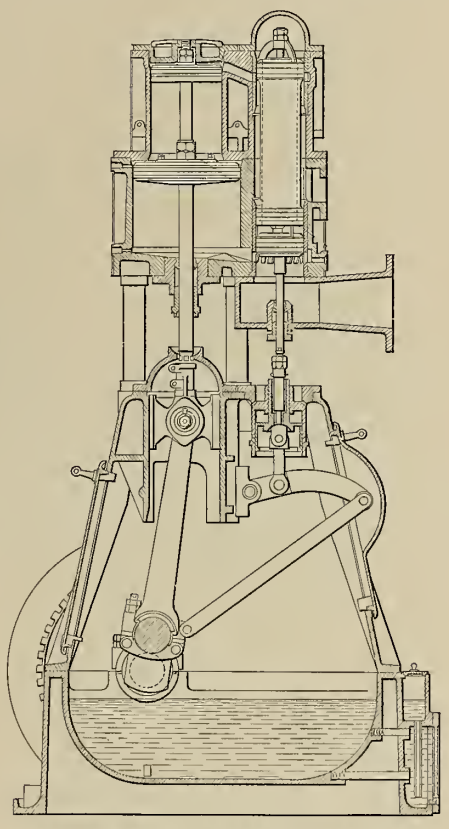
station, the extraordinary high mechanical efficiency $\left(\frac{\text{B. H. P.}}{\text{I. H. P.}}\right)$, at full load, of 96.3 per cent., was shown.

It is not the purpose of this paper to offer an opinion on the relative merits of single-acting and double-acting engines for high-speed direct-coupled work, but rather to illustrate successful applications of both principles. A striking feature of the accompanying illustrations is the number of three-crank tandem engines shown, and thereby hangs a double tale of rhythm and vibration.

A double-crank engine does not give a perfectly even turning movement, and although the unevenness may not be perceptible on the voltmeter or even in the incandescent lamps, it takes liberties with the periods of an alternating current generator, so that when it is desired to run alternators, direct coupled to two-crank engines, in parallel, the periods do not absolutely synchronise and a heavy synchronising current passes between the machines, even if they can be induced to keep in step at all. Usually a flexible coupling or even our old friend, the belt, has to be employed to provide some flexibility between the uneven turning engine and its alternator.

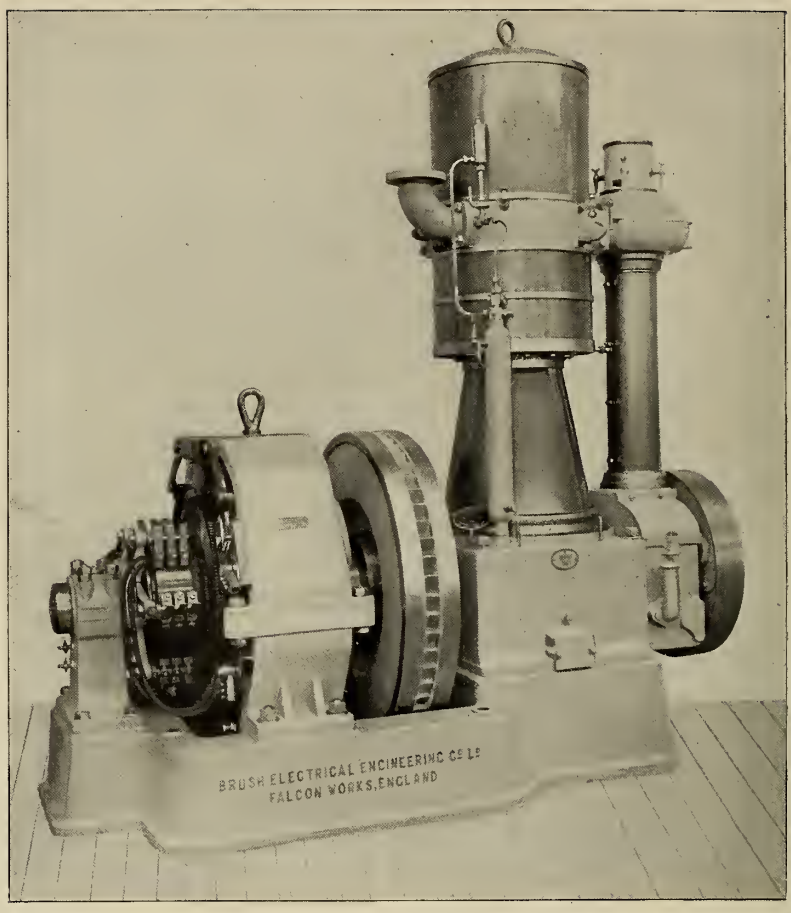
With the three-crank tandem engine these difficulties disappear; the turning movement of a three-crank tandem engine is so nearly even that the synchronising current between alternators driven in parallel by these engines is insignificant, and no flexible coupling or other device is needed.

Of more general importance than the extreme evenness of turning is the practical absence of vibration in a three-crank engine. In a double-crank engine, if the connecting rods were of infinite length and the cranks placed (as is usual in two-crank high-speed engines) opposite to each other, the inertia of one line of pistons would exactly balance that of the other line, so far as the total vertical forces are concerned. Of course, there would be an unbalanced couple which would be very objectionable on board a vessel, but which does not cause trouble from vibration on properly laid foundations. At each revolution of the engine there are two complete periods in which the unbalanced inertia force passes from a positive to a minus quantity of considerable magnitude. These unbalanced forces cause a pulsation in the foundation on which the engine stands which may be transmitted to adjacent walls and buildings, and may even, indeed, be transmitted through considerable distances where the soil is not solid.



VERTICAL SECTION OF THE PEACHE ENGINE.

In the three-crank engine the inertia forces, developed in the three lines of pistons almost entirely eliminate one another so far as total unbalanced vertical forces are concerned. There is an unbalanced couple left, but not of such magnitude as that in the two-crank engine, and, as it has been already pointed



THE "UNIVERSAL" ENGINE, BUILT BY THE BRUSH ELECTRICAL ENGINEERING CO., LTD, LONDON.

out, it is not the unbalanced couple that does the harm. Both on account of even turning and absence of vibration the three-crank compound engine has come to be regarded as the standard for central station work.

The first of the illustrations of modern high-speed direct-coupled sets is that of a Brotherhood three-crank compound engine, coupled to a Brush Company's Victoria dynamo. As already mentioned, Mr. Brotherhood was the first to combine engine and dynamo in one. The original application of this system was for ship lighting, and that, so far as its connection with electrical work is concerned, forms the principal field for the use of the Brotherhood high-speed engine. The engine itself long antedated the era of electric light, and had found extensive applications in other directions, notably as a hydraulic engine for capstans, and in the diminutive compressed air engines which drive the Whitehead torpedo to destruction.

Passing to engines which form the more immediate subject of this article, the place of honour must be given to the Willans engine. It was owing to the efforts of the late Mr. Willans, seconded by those of his partner, Mr. Robinson, that the high-speed engine emerged from the cloud of an extravagant steam consumption under which it rested and won the position, on a level with the most economical steam

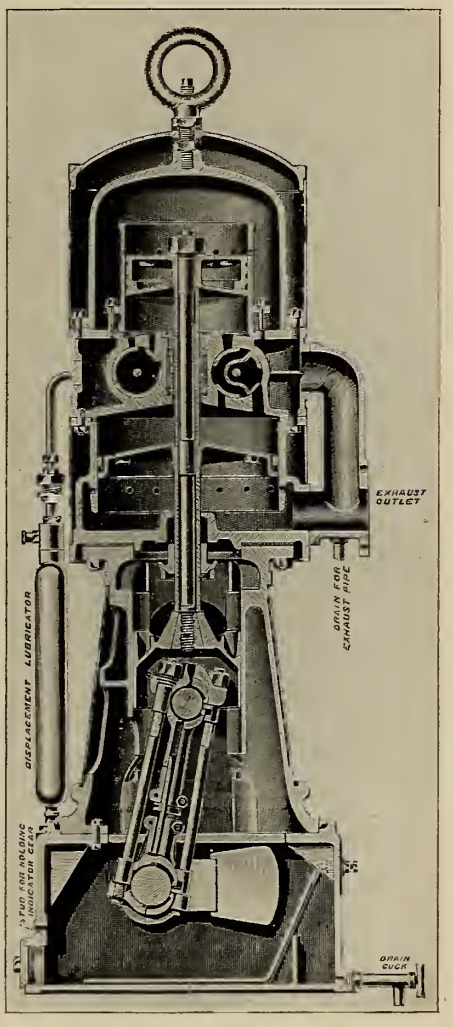
engines of the present day, which it now occupies. The example illustrated on page 345 is that of a triple expansion engine coupled to a Siemens multipolar dynamo at the Bradford electric light station. The engine runs at 300 revolutions per minute, and will give 700 I. H. P., non-condensing.

The piston rod is hollow, and inside it works a piston valve. This valve is driven from an eccentric, formed on the journal of the crank instead of on the main shaft, as usual, the required movement of the valve being relative to the pistons. The passages for admission and exhaust are opened alternately for each cylinder by this central piston valve, but the cut off is effected by ports in the hollow piston rod passing within the glands which are fixed on the top of each cylinder to separate it from the receiver above. Thus not only can the cut off for each cylinder be adjusted to the best point by the position of the gland rings above the cylinder, but the cut off is extremely sharp, the port in the piston rod remaining full open until, in the downward stroke of the piston rod, the port passes through the gland.

The length of the ports is that due to the thickness of the hollow piston rod, so that the cylinder clearances can be reduced to a minimum. The temperature to which the surfaces are exposed falls continuously from the high-pressure cylinder at the top to the low-pressure cylinder at the bottom, and the range in each cylinder is completely separated from that in the next by the receiver which intervenes between them.

The engine is single-acting. The steam pressure acts in a downward direction, and the upward inertia of the piston and other parts is balanced by an air-cushion cylinder situated in the crank chamber. Lubrication of all bearing surfaces is effected by the bath of oil and water in which they run. This effective method of lubrication has since been adopted by most makers of high-speed engines. The Willans central-valve engine was not only the first high-speed engine to gain a reputation for central station work, but is also by far the most largely adopted for that purpose at the present time.

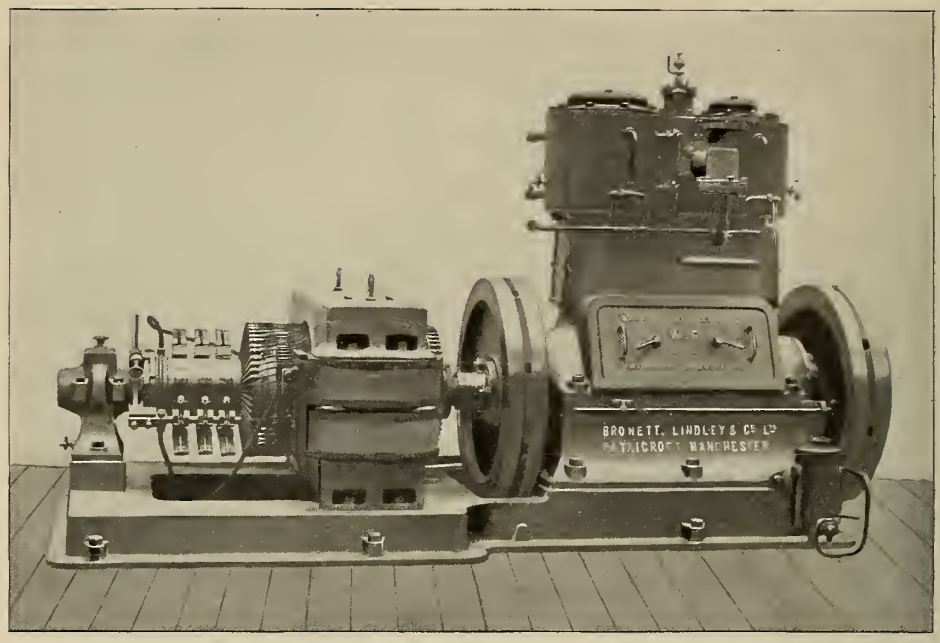
Next in importance to the Willans engine is that made by Messrs. Belliss & Co., Limited. This engine is double-acting. Lubrication is effected by a system of forced oil supply, introduced



VERTICAL SECTION OF THE BRUSH COMPANY'S "UNIVERSAL" ENGINE.

by the makers. The steam consumption is low, and, coupled with the high mechanical efficiency already alluded to, the Belliss engine ranks as one of the most economical of steam engines.

The one illustrated is a three-crank tandem compound, a type of which



ENGINE BUILT BY MESSRS. BROWETT, LINDLEY & CO., LTD., MANCHESTER.

Messrs. Belliss are making large numbers for electric light and power-transmission work. Steam distribution is effected by piston valves, placed at the side of each set of tandem cylinders and driven by eccentrics on the crankshaft.

Chandler's high-speed engine, made by Messrs. Bumsted & Chandler, is a single-acting engine working on the Willans cycle, viz., the work in all cylinders is done on the down stroke, but the valves are placed outside the cylinders, and the cut off, and the other functions of steam distribution as well, are effected by the valves only. The upward inertia of the pistons is balanced by compression of steam in the cylinders, although since the Willans & Robinson patent ran out, the air buffer has been applied by Messrs. Bumsted & Chandler to some of their engines for this purpose. Lubrication of the bearings is effected by a bath of oil and water.

Messrs. Bumsted & Chandler have for many years supplied a number of engines for smaller powers and are also doing a good deal of work in larger sizes for central station work. The engine illustrated on page 344 is a three-crank tandem-compound of 170 I. H. P. running at 380 revolutions per minute. The valves are placed at an angle of about 45° behind the cylinders, and are driven through a rocking lever by an eccentric on the crankshaft. This arrangement has been introduced by Mr. Chandler in order to save the room which would be taken up if the valves were placed in line with the cylinders.

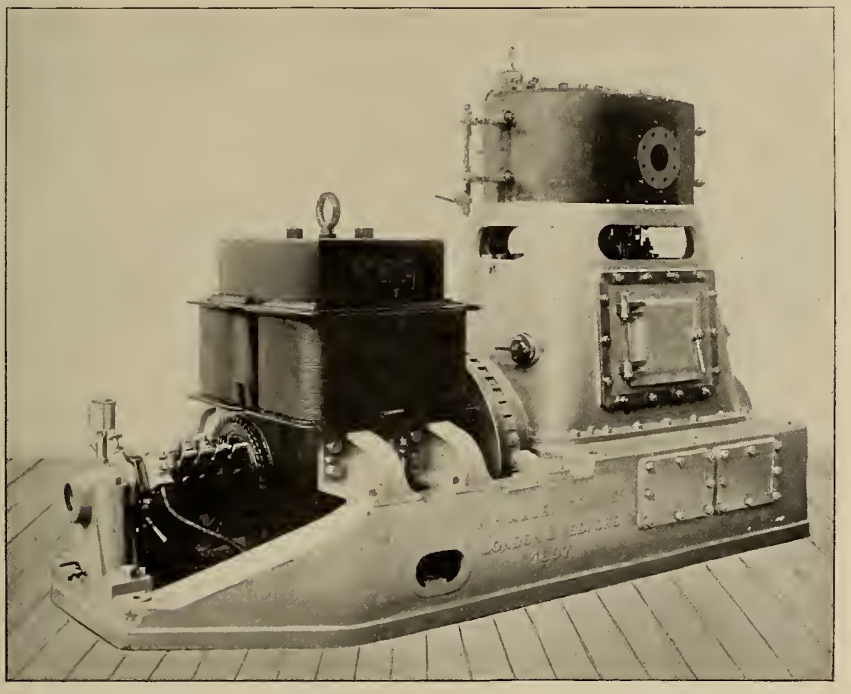
A more recent type of high-speed engine is the Peache engine, made by Messrs. Davey, Paxman & Co. This also is a single-acting engine, and lubrication of the bearings is effected by a bath of oil and water. The valves are placed at the back of the cylinders and are driven by a link that takes on to a point on the connecting rod. Steam acts on the top of the high-pressure piston and on the under side of the low-pressure piston, the space between the pistons being utilised as a steam cushion cylinder. The compression of steam in this cylinder, together with the receiver pressure, which acts on the top of the

high-pressure piston during the upstroke, is sufficient to balance the upward inertia of the pistons and so keep them "single-acting."

The valves are kept "single-acting" by means of an air buffer cylinder. The pressure in this cylinder, combined with the receiver pressure, which always acts in a downward direction on the valves, is sufficient to balance the upward inertia of the valves. The engine illustrated on page 346 is a three-crank tandem compound of 112 I. H. P., running at 500 revolutions per minute.

From the sectional view given on page 347 it will be seen that the design of the engine is simple, there being no internal glands. All parts are readily accessible. The arrangement of the valve gear permits the cylinders to be placed close together, giving compactness, while at the same time room is left for large and well-supported bearings. The steam cylinders are isolated from the working chamber, thus avoiding both the danger of overheating the lubricant bath, or, in the case of condensing engines, the danger of drawing oil into the condenser.

Since its introduction a few years ago Messrs. Davey, Paxman & Co. have supplied a large number of these engines for central station work. With regard to economy, Professor Kennedy, in reporting on a trial which he carried out on the first engine of this type that was made, said:—"The results, both as to efficiency and economy, for an engine of this size and working non-condensing, were quite first-class."



ENGINE BUILT BY MESSRS. W. H. ALLEN, SON & CO., LONDON.

Since this first experimental engine was built many improvements have been made, and the builders claim that the Peache engine now made by them is equal in economy to any other make of high-speed engine.

The next engine illustrated (page 348) is the Universal engine, the invention of Mr. I. S. Raworth, and made by the Brush Electrical Engineering Com-

pany, Limited. It is a double-acting engine. Lubrication of the bearings is effected by a rotary pump, which delivers a stream of oil over the working parts. Mr. Raworth relies on this means of lubrication to keep a constant film of oil between the bearing surfaces. All bearings are fitted with ready means of adjustment, and the makers claim that, when once the bearings are properly adjusted, the film of oil effectually fills up all slack, and the engine will run continuously without knock or appreciable wear.

Steam acts on the under side of the high-pressure piston, the upper side of this piston being subject to the intermediate receiver pressure. The steam then passes to the upper side of the low pressure piston, the under side of which is always in communication with the exhaust. Steam is distributed by two valves of Corliss shape. The function of one of these is to admit a cut off steam to the high-pressure cylinder, and this is driven by an eccentric, the position of which is controlled by a shaft governor. The function of the other valve is to control the exhaust of the steam from the high-pressure cylinder and to deal with the complete distribution of steam in the low-pressure cylinder. This latter valve is driven by a fixed eccentric.

Owing to the use of Corliss valves the cylinder clearances can be made small and the whole arrangement of the engine compact. The makers claim a low steam consumption and also the high mechanical efficiency which is obtainable with a high-speed double-acting engine.

Another high-speed double-acting engine has been lately introduced by Messrs. Browett, Lindley & Co., Limited. The engine illustrated on page 350 is of 60 B. H. P., and runs at 450 revolutions per minute. All bearings, as in the Belliss engine, are supplied with forced lubrication. A piston valve, situated between the high-pressure and low pressure cylinders, effects the distribution of steam. This piston valve is actuated by an eccentric under the control of a shaft governor.

The last of the illustrations (page 351) is also of a double-acting engine working with forced lubrication. This engine is made by Messrs. W. H. Allen, Son & Co.

USE OF ELECTRIC MOTORS IN PAPER MAKING.

By Dr. Louis Bell.

IN the opinion of the writer, expressed in a paper recently read before the American Paper and Pulp Association, the first and greatest use of electrical apparatus in paper making is in supplying cheap motive power from waterfalls, enabling the mills to be located at points favourably situated with respect to cheap raw material and easy shipment of product. These advantages once gained, the power can be delivered from the nearest available waterfall at a cost generally lower than the local cost of steam power.

It must be distinctly remembered that power thus transmitted electrically is not necessarily cheaper than steam power, but in a very large number of cases it is. From the investigation of probably several hundred propositions of this kind, I feel well within the bounds of truth in saying that with coal at about $3 per ton, the electrical transmission of 500 horse-power or more from an average water power anywhere within a radius of 15 miles will pay nine times out of ten. This is the case with power transmitted for ordinary purposes, and when, as in paper making, power is often used continuously throughout the twenty-four hours, the conditions become even more favourable for electric working.

At the present time there are above a hundred electrical power transmission plants operated from water powers in the United States alone. A number of them have been working for five years or more, and I have yet to learn of a single case in which these plants have been unable to compete with steam power on satisfactory terms, save in the case of some very large steam plants. Transmission has uniformly proved successful, both in the matter of cost and in reliability, which in many industries is quite as important. And in paper-making regions water powers can generally be more cheaply secured and developed than when they are located near a city which furnishes in itself a good market for power. I am glad to say that in a few instances transmitted power is actually in use in paper mills, and all the reports received seem to indicate the success that was to be anticipated.

There is nothing experimental in electrical power transmission under ordinary circumstances. The apparatus as now constructed is as manageable and reliable as steam apparatus and may be installed with the same assurance of success. Until within the past three or four years one would have hesitated to advise driving from water power, either directly or indirectly, any machinery requiring uniform speed at varying load. Now, however, water wheel governors are regularly in use which are able to hold the speed with an exactness quite comparable with the governing of a good steam engine. There are few places where uniformity of speed is more highly valued than in a cotton mill, and there are now a half dozen large American mills relying entirely on electrically transmitted power — and using it because it is actually cheaper than steam power, although some of the very best steam practice is to be found in the cotton industry.

I can in no way better emphasise the

money side of the problem than by making an estimate for a typical case. Let us assume the case of a mill which requires, say, 1000 horse-power, delivered continuously for all purposes. Near the proposed site of the mill there is merely a stream big enough to supply water for general purposes, but 10 miles away is a good water power which can be secured without unreasonable expense. What will be the cost of the power-transmission plant necessary to do the work?

To begin at the power house, we must allow, say, 1000 kilowatts in capacity, with preferably a generator in reserve, say, three 500-K. W. direct-connected machines, if the speed of the wheels will allow. The market price of such machines, complete with station equipments, and wound for 5000 or 6000 volts, including installation, will not exceed $10,000 each. It is almost unnecessary to state that for a transmission of this length one of the poly-phase systems would always be installed. The present tendency is toward high-voltage generators, connected directly to the line for such cases, although low-voltage generators with raising transformers can be obtained for not far from the same price. In any event, reducer ing transformers for 1000 horse-powe would have to be installed at the mill, in large units of which the aggregate cost would not exceed $5000 to $6000.

The 1000 horse-power in motors would be needed for driving the various parts of the mill, and assuming units of 100 horse-power or more, the probable cost of these motors would be $15,000 to $20,000, depending somewhat on the size and speed of the various units. This completes the necessary electrical machinery. The line, assuming, say, 6000 volts delivered, and 10 or 12 per cent. drop, could be erected with all copper up for less than $20,000. Altogether, the machines at both ends of the line and the line itself could be installed, including a suitable station, for about $80,000; under favourable conditions for somewhat less.

The cost of the water privilege and the necessary hydraulic work is the most uncertain factor in working out any assumed case of power transmission. It may fall even to $25 or $30 per horse-power, and it may rise to $150 or $200. Taking the general average of powers in regions where they have not yet acquired an artificial value by proximity to towns, one may say without being widely astray that $75 per horse-power will cover the necessary expense. With a considerable head this figure will be somewhat reduced.

For a rough estimate of the hydraulic cost in the case in hand, we shall be fairly near the mark in doubling the cost of the electrical part of the equipment, making $160,000 as the total investment in the power plant for furnishing 1000 horse-power day and night. A brief expense estimate will show how important a saving can be effected by this utilisation of electric power.

This figure of $160,000 is certainly conservative enough, since I have in mind one plant with a generating station of 1000 horse-power which was installed complete, including distribution lines to the amount of $15,000, but no motors, for less than $125,000, and this at a time when electrical machinery was considerably more costly than at present.

As to operating expense, the figures are not difficult to secure. In the first place, we will allow for interest on the investment at 6 per cent., and will charge annually 4 per cent, to the credit of a sinking fund, for depreciation or replacement. Then we will add 2 per cent. for insurance and taxes—certainly an ample allowance. The total annual charge due to these items then becomes $21,600. We can then make up the regular operating charges about as follows:—Labour, eight men and team, $6500; supplies and general maintenance, $5000. These figures are more than ample for any ordinary case. Summing them, we arrive at $33,100 as the total annual cost of 1000 horse-power for twenty-four hours per day, which brings the charge per horse-power year down to $33.10. This power, generated by steam, with coal at, say,

$3 per ton, using the non-condensing engines too often employed, would cost at least double the amount mentioned, and even with a first-class steam plant the cost would fall little, if any, below $50 per year. In other words, the net yearly saving by employing electrical transmission in such a case as we have assumed amounts to from $15,000 to $30,000 per year. And this figure could often be exceeded under the conditions actually existing in paper mill work.

The question of electric heat for the drying rolls, and generally for freeing the pulp from water, has been several times broached to me recently. It is only fair to say right now to those interested that the amount of power required to furnish heat for drying the daily product of a modern paper mill is enough to stagger the wildest-eyed and longest-haired electrical crank who ever claimed that electricity was in its infancy. That drying by steam is expensive is painfully evident to any one in the business, but if you are inclined to seek for improvements do not take up electric heating until you have exhausted the possibilities of producer gas.

To sum up, the best field for the use of electric motors in paper manufacture is in reducing the cost of power, by utilising the now well-tried methods of power transmission. By this means a mill can be located so as to obtain its material and ship its product economically, without foregoing the advantages of cheap water power. With the transmitting energy at hand, power can be economised by the skilful use of motors in its distribution. There is no cut and dried rule or formula by which the best equipment can be at once determined. Each case has to be considered on its merits, and by the light of common sense, for in the last resort the best equipment is the one which enables you to turn out a given grade of paper at the lowest price.

NOTES ON CHIMNEY BUILDING.

By William E. Crane.

AMONG the perplexing things that come up when a chimney for a boiler plant is to be built are the cost and durability.

Those who have a small capital are apt to put up a guyed steel stack. The thickness of metal will vary from No. 10 to 3-16-inch, and the life, from two to ten years, depending upon the thickness, fuel, temperature of flue gases and number of hours run. Painting on the outside does but little to preserve such a stack, as the corrosion that destroys is on the inside.

Several years ago the writer put up a small stack and painted the inside with a mixture of coal and pine tar, filled it with shavings and set it on fire. This left a coat of carbon on the inside. The stack was a second-hand one, nearly half gone, but has given no trouble.

The larger, self-supporting stacks, made from metal from ¼″ to ½″ thick, will last longer, for the reason that there is more metal to wear out, and when the further precaution is taken to line them with brick, their life is still further prolonged. These stacks, however, are expensive.

When a man is about to put in power and finds that he has not the money to put up a brick chimney, he is very apt to have recourse to a cheap guyed stack, trusting that he may earn money enough to pay for another one when that one falls down. From this, the impression has gone forth that a steel stack is much cheaper than one of brick, and people that could afford it have put up the more

elaborate brick-lined, self-supporting steel stack under the impression that it costs about half as much as one of brick alone. But in this they made a mistake.

When the flue is over six feet in diameter and 125 feet high, the probability is that the brick chimney can be built for the least money, unless the locality is one where brick is exceptionally high in price.

A brick chimney should have a flue extending nearly to, but not connected at, the top of the outside shell. This inside flue will take the strain due to the expansion from heat, thus leaving the outside with no strain except from wind pressure. Moreover, whatever infiltration of air there may be through the outside shell will pass up through the space between the two shells.

It is important that good hard brick should be used, and it is of equally, or of greater, importance that good mortar should be employed, and enough of it to fill all cracks. The inside shell should be built with lime mortar, and the outside should have a mixture of cement, or all cement. As a further precaution, rim bands should be built in at intervals next the outer course of brick, and one or more at the top and bottom of the flue opening.

The top should be covered with a cast iron cap, put together with copper bolts, or else with a lead cap with joints burned together in place. There should be as little ornamentation as possible.

Rings put in near the top deceive the eye as to the point where the taper changes and add a little to the appearance, but they catch snow, ice and rain, which will, sooner or later, cause disintegration of the structure at that point. This same is true of the corners when a chimney is built square at the base up to a point above the flue opening and then changed to round.

WILLIAM HENRY PREECE, C. B., F. R. S.

A Biographical Sketch.

THE presidentship of the British Institution of Civil Engineers is rightly considered the highest honour that can be conferred upon a British engineer by the suffrage of his professional brethren; and Mr. W. H. Preece's recent election to that office will be heartily welcomed by his many friends on both sides of the Atlantic. To electrical engineers it is an incident of special and peculiar gratification, for he is the first of the long line of distinguished engineers who have occupied the presidential chair whose lifework has been entirely devoted to the practical application and utilisation of electricity and its cognate sciences in the service of that highly organised and complicated entity, our modern civilisation. It is also the first occasion on which the honour has been bestowed on a civil servant of the Crown.

William Henry Preece was born in the year 1834 at Carnarvon, the quaint, historical old town that calls itself "the capital of North Wales." He was educated at King's College, London, going through both the school and the college. He studied electricity under Faraday at the Royal Institution. In 1852 he entered the office of Mr. Edwin Clarke, C. E., the Engineer-in-Chief of the Electric Telegraph Company, and formally became attached to that company in 1853. Mr. Robert Stephenson was chairman of directors at the time, and the company shortly afterwards amalgamated with the International Telegraph Company, the combined undertaking being thenceforward known as the Elec-

tric and International Telegraph Company.

Mr. Preece's promotion was rapid. In 1856 he was made superintendent of the company's southern district; in 1860 he received an additional similar appointment under the London and South Western Railway, while in 1858 he became engineer to the Channel Islands Telegraph Company. In 1870 the business of the various telegraph companies, of which the Electric and International was by far the largest and most influential, was transferred to the State, and intrusted by the government of the time to the Post-Office. Mr. Preece followed his work, and was appointed divisional engineer for the Southern District of the Post-Office Telegraph System, being stationed at Southampton. He was promoted to the post of electrician for the whole system in 1877, when he removed to London, and was further promoted to be engineer-in-chief and electrician in 1892, an appointment which he still holds.

As an inventor, he has designed and perfected a large number of appliances for practical telegraph work. In 1855 he patented a new system of duplex telegraphy, and between 1862 and 1873 he secured a number of valuable patents in block signalling apparatus for railway working. During that period his attention was very closely engaged upon this subject, and his improvements on the primitive apparatus employed in earlier days were very marked and important. He also invented a method of communicating between different parts of a train while in motion (1861); working miniature signals by electricity to assimilate and combine outdoor and electric signals (1865); a method of counteracting the interference caused to electric signalling by lighting (1873); and an improved means of communication between passenger and guard (1882). By these means he added greatly to the safety of railway travelling, and, by perfecting the signalling arrangements, enabled the locomotive and permanent way engineers to meet the constantly increasing demands of the public for more rapid travel. He considers his work in this connection the most important of his life.

Since Mr. Preece's employment as an officer of the British Post-Office his work as an inventor has not been diminished, while to it has been added the duty of developing and perfecting the inventions of others. The enormous advances made in the efficiency and capacity of telegraph apparatus and lines since he became chief of the technical branch of the service form a splendid monument to his industry. The speed of the Wheatstone automatic apparatus has been increased by a series of brilliant devices from 80 to 600 words per minute for comparatively short lines, while the speed attainable between London and Dublin reaches 450 words per minute. The practical working and improvements in the duplex, quadruplex, and multiplex systems have increased the capacity of wires for hand manipulation or key working up to a maximum of six times its original value.

And improvement has not been in the telegraphic apparatus alone. The claims of the telephone have received full attention, and increased efficiency has been secured in telephone working. As regards the apparatus, Mr. Preece can fairly claim to be the originator of the automatic call and visual signalling systems now largely adopted in a variety of forms in the United States and on the British Post-Office trunk lines. But his most important contribution to telephone work has been the evolution of the "K. R." law, which determines the telephonic value of any given electrical circuit from its total capacity (K) and resistance (R). In the specification of trunk telephone lines, and in designing submarine cables for telephonic purposes, this law has been of immense value to telephone engineers.

In the improved construction of telegraphic lines also he has played an important part. Line construction in the early days was not considered a matter of great importance, and the early lines were weak and badly put up. A terrific blizzard in 1866 played havoc with them. The need for stronger poles and

more of them, with better staying and improved construction generally, was forced upon Mr. Preece and others acting with him; and the result was that British telegraphic lines became works worthy of the engineer, whereas before in many instances they would scarcely have done credit to a bell-hanger or a clothes line erector.

The demands of high speed telegraphic apparatus and of telephones also brought about a revolution in the conductors used on the lines. Iron was quickly found to be unsuitable, and Mr. Preece early called attention to the superior qualities of copper. In 1883 and 1884 long experimental copper lines were erected, and the resulting increase in the speed of signalling practically determined the further use of copper on the principal circuits. Now the amount of copper wire being erected by the British Post-Office largely exceeds the amount of iron.

Mr. Preece's recent work in connection with the problem of establishing telegraphic communication across space without connecting wires, or, as it is popularly, though somewhat erroneously, termed, "wireless telegraphy," has attracted a large amount of attention, both from the scientific world and the public at large. He has thrown himself into the investigation with all the zeal he showed nearly forty years ago when he was grappling with the question of railway signalling. And his policy in this matter has been fully representative of the two broad methods which he has followed throughout for the improvement of the apparatus and systems of working under his care.

It is well known that the experiments which he initiated resulted in the development of a perfectly practicable and reliable method of signalling across space, provided the distance be not excessive. The system was established for a short time to communicate with one of the Scotch islands from the mainland, and worked without a hitch. Up to this point everything that had been done by the Post-Office originated with Mr. Preece himself or with his assistants. Then a young Italian inventor appeared with something that seemed, on investigation, to promise better results, and he at once put the full power of the department machinery to the task of developing this new system. The independent inventor is always welcome if the invention he brings bears the hallmark of genuineness. The use of Stearn's system of duplex working, Edison's quadruplex, and Delany's multiplex, all plants of American growth, are standing memorials to the fact that the British Post-Office, under Mr. Preece's advice, recognises no citizenship in matters of invention, but utilises what it thinks best for its purposes regardless of the consideration that it may be of foreign origin.

Mr. Preece thoroughly deserves to be regarded a pioneer of electrical industry. He brought the first electric bells to London from Paris in 1863. The stir caused in scientific circles in 1876 and 1877 by the invention of the telephone by Dr. Alexander Graham Bell, induced the British Post-Office authorities to send him to the United States in the latter year, to inquire into the matter. He brought back with him the first pair of telephone receivers that reached England. He also introduced the phonograph to the British scientific societies. On electric lighting, electric traction, and the electric transmission of power, he has always been in the front rank of British authorities, and a recognised adviser of successive governments in legislative enactments and other measures for the authorisation and control of electrical undertakings.

As a writer on scientific and electrical subjects he is well known. His "Manual of Telegraphy," written in conjunction with (now Sir James) Sivewright, has passed through many editions. He is also joint author, with Dr. Maier, of "The Telephone," and with Mr. A. J. Stubbs, of a "Manual of Telephony." But perhaps his highest claim to distinction in this connection is derived from the multitude of papers which he has written for the various scientific and engineering societies to

which he belongs. To enumerate the titles merely of all these would occupy pages of this publication.

That Mr. Preece is well known and highly popular as a public lecturer the crowded audiences that gather at the Royal Institution, the Society of Arts or other venue selected for any of his discourses, fully testify. The matter which he presents is good, and his manner of presenting it is beyond reproach. His success with delicate illustrative experiments in the lecture room is very marked, and, in the event of a failure in this respect, he has always ready a good-humoured observation appropriate to the occasion, which disarms critical observers and causes the laugh to be with him rather than at him.

Neither is he lacking in those less serious qualifications which are necessary for the equipment of the successful after-dinner speaker. Indeed, it may be said that he is never more thoroughly at home than when he rises at some festive gathering to propose or respond to one of the toasts. One sees that movement of animated expectancy on the part of the guests which betokens that they know their man. Nor does he disappoint. The appropriate anecdote, the apt quotation, the humorous and always good-humoured paraphrase of the remarks of previous speakers, make the lot of the diner a pleasant one while Mr. Preece is on his feet. His power of happily conceived impromptu is well developed.

A single instance to illustrate his readiness in this respect may be pardoned here. Not long ago at a public dinner when his turn came to speak the pompous toastmaster announced him as "Mr. W. H. *Pearce*." There was, of course, a laugh. Mr. Preece bowed deferentially, and said, "Gentlemen, lest there should be some lingering doubt in your minds, I beg to inform you that I am the man."

Notwithstanding the continuous and heavy demands made upon him by the actual work of his office, Mr. Preece has found time and opportunity for a fair amount of travel. He has paid three visits of some duration to the United States and Canada,—in 1877, in 1884 when the British Association held its annual meeting at Montreal, and in 1893 on the occasion of the World's Fair at Chicago. His enjoyment of the visits was most keen, and he felt severely last year the deprivation of a renewal of former delights when great press of official work and ill health prevented him from crossing the Atlantic again to attend the second meeting of the British Association in the New World, at Toronto.

He has also visited, either as a member of telegraphic conferences or in some other official capacity, France, Germany, Sweden and Norway, Spain, Italy, Austria-Hungary, Egypt, Holland and Belgium. He has been closely associated with the management of almost every European international exhibition for the past twenty years, as a member of committee, council, or royal commission; and he is now acting on the royal commission recently appointed for the Paris International Exhibition of 1900. He also served on the royal commission dealing with electrical communication with lighthouses and lightships (1892-1897), and his unique knowledge of electrical signalling in all its phases was of great service in that connection.

Mr. Preece is a member of many scientific societies. He entered the Institution of Civil Engineers as an associate in 1859, became a member in 1872, and, after serving a long period on the Council as ordinary member and vice-president, has now been advanced (April, 1898) to the highest office in the Institution, the blue ribbon of the profession. He has been president of the Institution of Electrical Engineers twice, and of Section G of the British Association at its Bath meeting in 1888. He received the coveted scientific distinction denoted by the letters "F. R. S." in 1881, and he is also a member of the Physical and Meteorological Societies, the Royal Institution, the Society of Arts, and the British Association. He was appointed an officer of the Legion of Honour by the President of the French Republic in 1889, and a

Companion of the Order of the Bath in 1894.

Mr. Preece's town residence is Gothic Lodge, Wimbledon, a quaint old house on the borders of the well-known and beautiful Wimbledon Common. It was once the residence of Lady Ann Lindsay, the authoress of "Auld Robin Gray." Here is to be found the celebrated collection of Persian curiosities, said to be the finest of its kind in Great Britain. This collection is one of Mr. Preece's pet hobbies, and he has spent much time and money upon it. He has had a willing helper in the person of his brother, Mr. J. R. Preece, for many years an official in the Indo-European Telegraph Service, and now British Consul at Isaphan. He has also a residence in North Wales, near Carnarvon. He is a charming host, and all who have enjoyed his hospitality desire an opportunity to renew the experience He has a family of four sons and three daughters. Three of his sons have adopted the profession of their father; the fourth is a qualified solicitor.

It will be seen from the foregoing that Mr. Preece has been an indefatigable worker during the whole of his active life. His has been a career of steady industry and unwearying perseverance. There has been no special period of unrest or excitement, and no stirring adventure to break the continuity or check the progress. The rate of advancement has varied, but there has been no going back, no actual stoppage of the forward movement. Macaulay's comment on the Baconian philosophy can be applied not inaptly to his life's work:—"A point which yesterday was invisible is its goal to-day, and will be its starting post to-morrow."

To labour for sixteen or eighteen hours a day for weeks at a time is to him no unusual occurrence; but hard as he works he always has a keen relish and appetite for it. It can be said of Mr. Preece, if of any man, that he puts his soul into his work, and his career proves again the truth so often proved before that "he who works with his whole soul knows no drudgery."

J. W. CURRA.

Current Topics.

To the "foreign devil" who would cater to the Chinese trade it is of the first importance almost to study well the matter of trade-marks, for upon the circumspection with which these are chosen will depend largely the fate of the goods. Mr. Samuel L. Gracey, United States Consul at Fuchau, in one of his recent reports, gives a list of some of the pictures most frequently seen, and which, therefore, presumably are popular and would lend themselves well to trade-mark use. But simply naming these things does not supply sufficient data from which to prepare them. It must be remembered, so Mr. Gracey tells us, that Chinese art is very peculiar, and a tiger, as ordinarily represented by foreign artists, would not meet with favour with John Chinaman. It must be a tiger according to Chinese imagination and art, of unreasonable length of body, or bigness of head, or curve of tail, and in impossible attitudes. On a popular Japanese match box is displayed a monkey standing on its front feet, head nearly touching the ground, with hind feet up in the air, and tail whipping the skies. The grotesque and even hideous, to European and American minds, tickles the fancy of the dwellers in Far Cathay. No description can supply adequate information to an engraver or colourer by which he could produce the real thing, and any departure from the Chinese fancy in such things would brand the goods at once as foreign product and doom it to defeat.

A CHINESE dragon differs from a Japanese dragon in its contortions. A royal dragon must have five claws, while the plebian beast has only four. A stork must always stand on one leg, or, flying, must present an enormous spread of wings and trailing long legs. All Japanese birds, when flying, must have a tendency downward, never up or on a straight course. To a Japanese, nothing is preferable to the representation of snow-capped, sacred Fusiyama, as seen on nearly all Japanese fans, screens, and other articles. One of the labels mentioned by Consul Gracey represents a woman in bright robes, holding a long-necked vase on her shoulder, while at her side is a monkey holding a chrysanthemum in its mouth. Others are equally grotesque. But they all are suggestive of the curious fancies of those of the Celestial Empire.

THAT there should be economy in heating feed water with live steam was

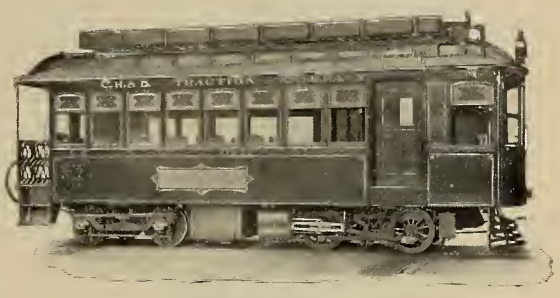
at one time a matter of wondering comment among engineers; but it is more than half-a-dozen years ago that Mr. John Kirkaldy's claim of such economy was very completely substantiated by disinterested observers, and in the intervening period Kirkaldy live steam feed-water heaters and their derivatives have grown and multiplied the world over. To-day the fact is unreservedly accepted that they bring splendid returns to their users. Reference to them at this time has been prompted by the attention which live steam feed-water heating received at the last meeting of the British Institution of Naval Architects, but at which, strange enough, Mr. Kirkaldy's pioneer work seemed to be quite forgotten. In an article which appeared in the April number of this magazine, in 1893, it was stated that when Kirkaldy first proposed to use live steam for heating feed water, he had no idea of securing a saving of fuel by the method. He simply thought that it would be a good thing in the case of freight steamers, usually pressed for time, if their boilers, after being emptied in port, were filled up with hot water instead of cold. He, therefore, rigged up apparatus by which a donkey boiler could supply steam to heat the cold feed before it was pumped into the main boilers. As this worked well, he extended his operations so that the feed could always go in hot, not to save coal, but to prevent the strains which cold feed water is apt to set up in a boiler. He argued, probably as others would have argued, that the steam could give up no more heat to the feed water than it withdrew from the boiler, and that, therefore, of course, there would be no economy. But it turned out that the boilers which received the hot feed steamed better than before, and later trials showed that there was actually a very considerable economy in the method,—something like 10 per cent. Of course, Mr. Kirkaldy's statements at that time excited open derision; they were so palpably absurd,—the whole thing so clearly impossible. But he has had his revenge. Thermodynamic considerations have grown broader in the past few years, and engineers are satisfied to-day that the Kirkaldy heater, after all, accomplishes exactly what is claimed for it, and what might, reasonably enough, have been expected.

Apropos of the best location for discharge tubes on torpedo-boats, Lieutenant R. C. Smith, U. S. N., in a paper presented some time ago to the United States Naval Institute, arrived at the conclusion that, as a general rule, it is most advantageous to install torpedoes in single tubes pivoted on the central fore-and-aft line, and at some distance from the ends of the boat. In the case of small boats, the short torpedo would be permissible, as the boat's beam would not be great enough to materially reduce the angle of train, were it not that, as a type, it has not been found sufficiently accurate to warrant its further manufacture. It has been generally abandoned in Europe. The standard torpedo for torpedo-boats is the long 18-inch, on account both of its greater accuracy and its larger explosive charge. While the weight is less than thirty per cent. greater than that of the short 18-inch, the guncotton charge is over 83 per cent. greater. The greater accuracy is due simply to its greater length,—16½ feet, against 12. Two or three tubes may be carried, according to the size of the boat. The end of the spoon is from 11 to 12 feet from the pivot, which takes the torpedo well clear of the side of even a large boat. By having a torpedo carriage with the pivot towards the breech rather than the muzzle, the sweep of the spoon could be still further increased, and angles of train exceeding 90 degrees could be obtained on each broadside of a boat of 20 feet beam. If a light torpedo be required, the long 14-inch torpedo is considered far preferable, by reason of its greater accuracy, to the short 18-inch. The explosive charges are about the same. Smokeless powder, Lieutenant Smith thinks, will probably replace all other means of discharge. Air and steam re-

quire extra weight and are otherwise complicated. They are already practically replaced by gunpowder. This affords a simple means of discharge, but the pressures vary greatly with dampness. Smokeless powder gives more uniform pressures, is practically unaffected by dampness, and does not foul the tube.

UNTIL quite recently the bow torpedo tube, with steam, air, or gunpowder impulse was the most common. In some cases there were two such tubes, side by side, referred to as twin tubes. These answered fairly well when the speed was not so high as it is at present, but now the bow tube makes the boats wet in a sea-way, and it could scarcely be used except in smooth water. At high speeds there is also danger of overrunning the torpedo should it not attain its own speed quickly. By omitting these tubes, enough weight is saved to build up the bow forward and improve the sea qualities. Tactically, the bow tube, requiring to be pointed by the helm, is not so desirable as a pivoted tube with a large angle of train. Then, too, in approaching the enemy at high speed, it is awkward to have to stop and back, or else make a wide sweep, during which the boat's broadside becomes the best possible target for the enemy. With pivoted tubes, the boat can begin the turn before delivering the first torpedo, and with a small helm can launch in succession all that will bear on one broadside, and then, putting the helm hard over, can soon be out of danger. The stern position is also good tactically, and is not open to objections on account of weather. If, however, the torpedoes are stowed for long in tubes in this position, they are affected by the vibrations due to the propellers which are there at a maximum.

AN interesting example of American steam motor car for interurban transportation line service has latterly been put in operation on the Cincinnati, Hamilton and Dayton Railway Company's system at Hamilton as a means of successfully meeting the competition of electric lines. The outfit has been modeled somewhat after the comparatively well-known Rowan motor car of earlier years, which has been used in Europe with a fair measure of success, and of which a prominent feature is freedom from smoke and waste steam nuisance. At present the car runs between the two towns of Hamilton and Middletown, and will be reinforced by a number of others should the service prove all that is expected of it. The frames supporting the cylinders and driving mechanism are embodied in a swivelling truck which forms a support for the forward end of the car. The steam pipe connecting the steam

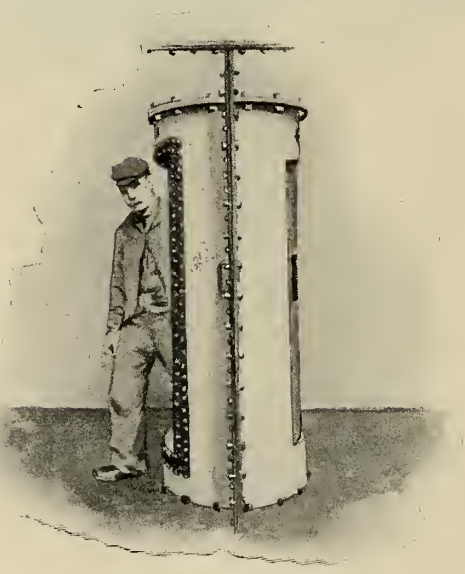


A NEW STEAM MOTOR CAR.

chest with the boiler is provided with flexible metallic joints to allow for the lateral motion of the cylinders caused by the swivelling motion of the truck. Feed water is supplied by two injectors. A four-wheeled swivelling truck, acting simply as a carrier, is placed under the rear end of the car The car body measures 32 feet over all, and is divided into passenger, baggage, and engineer's compartments. The passenger compartment has a seating capacity for 24 persons and has transverse seats, with an aisle in the centre. A condenser is attached to the roof of the car into which all the steam from the cylinders may be diverted. Two tanks, each with a capacity of 150 gallons, are placed under the car body, from one of which the feed water is taken, whilst the other, being connected with the con-

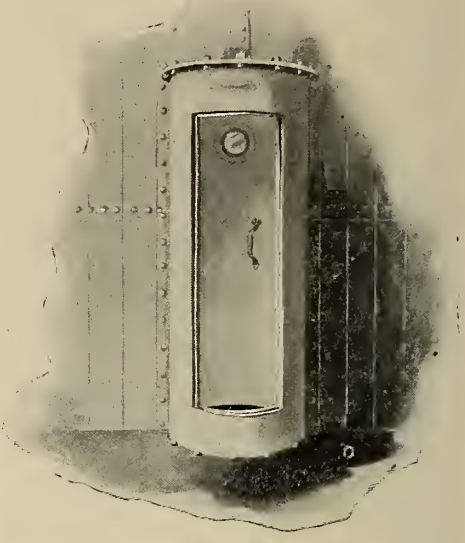
denser, receives the water formed by the condensing steam; but both these tanks are connected and supply the feed water to the boiler. The latter is of the centrally fired, self-feeding type, and is supplied with anthracite coal or coke from the car roof. In the tests which have been made, the fire required no attention during a run of 38 miles.

THERE have in recent years been few marine disasters which have not brought up directly, or indirectly, the matter of water-tight bulkheads and the doors with which they are provided. Sermons, almost endless, have been preached and written about them, their obvious advantages have been extolled, and their weaknesses as well have been pointed out with a view to a betterment of things; and yet, often, when most needed, in dire distress, the bulkhead system has basely failed to give that fancied security upon which so much reliance had been placed. Bulkhead



A NEVER-OPEN BULKHEAD DOOR.

doors would have a fashion of being open when they should have been closed, and human agency to close them at the critical moment has often enough proved fatally fallible. It has been well said, in fact, that the only way to have closed bulkhead doors at the right time was to have no doors at



A FRONT VIEW.

all, and in a few transatlantic liners the "no-door" policy has been rigorously and most commendably carried out. Central station power systems, too, have been devised by means of which all doors throughout a ship can be closed simultaneously by a single operator from one point, but they are yet in their beginnings, though clearly destined to accomplish much good.

ONE other system which has been introduced is that of the Kirkaldy revolving door, designed by Mr. William Kirkaldy, of Glasgow. The arrangement consists of a hollow cylindrical casing, bolted to the water-tight bulkhead, one-half of the cylinder being in one compartment and the other half in the compartment adjoining. In the casing are two doorways, one at the fore part of the circle, and the other at the aft part. Within the casing, and close fitting, is a hollow cylinder, which revolves easily, having one doorway in its circumference, of a

size corresponding to each of the doorways in outer casing. This cylinder is suspended by a central bolt overhead, and freely revolves on ball bearings. The revolving action is accomplished by hand, slots on the outside for the insertion of the fingers and handles on the inside being provided for this purpose. In other doors now being made, however, other means are being substituted for revolving the door, with the view of obviating any possible risk of damage to the fingers of any one hurriedly operating it. When it is intended to pass through the bulkhead, the aperture in the revolving cylinder is brought around to correspond with the doorway in the casing, and the person steps inside, revolves the cylinder, and, in doing so, of course, brings it around so that its one doorway corresponds with the doorway on the opposite side of the casing, thus giving egress into the compartment. The doorway by which entrance was had to the casing is, of course, absolutely closed before the revolving cylinder and its opening comes in line with the opposite doorway, allowing egress from the casing. The movements involved will be clearly understood from the two illustrations on the opposite page. The distinctive feature of this revolving double door is that it is impossible to leave it open at any time when passing through the bulkhead, one door having to be absolutely closed before the other opens. In this vital respect it meets a most excellent requirement. As at least a partial substitute for a centrally operated system of ordinary doors it would seem to admirably commend itself.

In view of the immense trial successes which wire-wound guns have recently had in Great Britain, the apathy of artillerists in the United States in regard to this class of ordnance is hard to understand. About three years ago, the United States gave a conditional order for a Brown segmental wire-wound 10-inch gun, to be built at the Scott Ironworks, at Reading, Pa. The weight of this gun was to be 30 tons and the length 37½ feet; the steel wire was to have a tensile strength of 120,000 pounds per square inch, and to be wound around the core at a stress of 98,000 pounds per square inch. Since then, though this gun may have been finished and tested, there has been no sign of the adoption of it or any other form of wire-wound ordnance by the United States Army or Navy authorities. It is true that the national gun factories at Washington and Watervliet have lately been so successful in turning out large built up rifled guns of the ordinary kind that American heavy guns have probably no superior in the world in strength and in accuracy of workmanship. But on the published figures, the British wire-wound guns, for equal calibres and weights, certainly seem to have the best of it. For example, the British 12-inch, 46-ton wire-wound gun, now the standard heavy gun used in the *Majestic* and *Canopus* classes, discharges an 850-pound shot with a muzzle velocity of 2367 feet per second and a muzzle energy of 33,020 foot-tons; the American 12-inch built-up gun of 45½ tons, with the same weight of projectile, has a muzzle velocity of only 2100 feet per second and a muzzle energy of 25,985 foot-tons; while the French 12-inch gun, of the same type of construction as the American, weighing 45.9 tons, with a lighter projectile of 643.8 pounds, has a muzzle velocity of 2625 feet per second and a muzzle energy of 30,750 foot-tons. On these figures, the British gun is indisputably superior to both the American and French guns, but the greater weight of the American projectile, as compared with the French, would make it superior to the latter at long ranges, owing to its greater momentum, while inferior to it at short ranges, owing to its lower muzzle velocity.

Powerful as the wire-wound 12-inch gun, made at the Royal ordnance factory at Woolwich, seems to be, it is proportionately surpassed by the per-

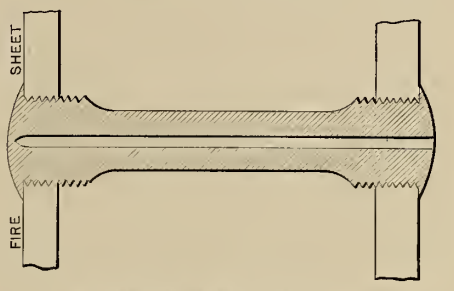
formance of the new Vickers 6-inch quick-fire wire-wound gun. This gun has a length of forty-five calibres, or 22½ feet, gives a muzzle velocity of 2748 feet per second, and weighs 7 tons, 8 cwt. With a 100-pound projectile it has a muzzle energy of 5374 foot tons, as compared with the 3356 foot-tons developed by the 6-inch quick-fire wire-wound gun at present used in the *Majestic*. With a charge of 25 pounds of cordite, its muzzle penetration of wrought iron is 22 inches, against 15.9 inches by the *Majestic* gun just mentioned. At 1000 yards it will penetrate 18.1 inches of wrought iron, and at 2000 yards 14.3. After firing 200 rounds with full charges, its accuracy was such that on two occasions the second shot followed the first through the same hole in the target. Surely these facts present a *prima facie* case for an exhaustive series of trials for wire-wound guns by the United States ordnance authorities. The first, or almost the first, man who believed in the practicability of wire-wound ordnance was the great Brunel, who designed *Lucanias*, huge bridges, big locomotives, and many other engineering wonders of modern times, before he had either tools or materials sufficiently good to manufacture them. Contemporary with him in projecting wire-wound guns were Longridge, in England, who ultimately made the first serviceable gun of this kind, and Woodbridge and Very, in the United States.

THE first experiments were made independently on both sides of the Atlantic in 1855, but nearly thirty years were to elapse before steel wire of sufficient strength and homogeneity was forthcoming. Meanwhile, beginning in 1854, Armstrong had converted the whole world to his system of built-up guns, and Whitworth brought to perfection the art of casting gun steel ingots. It was not until 1886, when the Bethlehem Iron Company, in the United States, bought the trade secrets of Whitworth & Co., that the United States was able to take its rightful place in the manufacture of steel ordnance. Probably the success of the Armstrong method turned men's minds for a time from the problem of wire-wound guns. Yet the old stump and twist barrel, known as Damascus twist, so highly valued by our fathers and grandfathers for rifles and fowling-pieces, was nothing but a crude wire-wound process, the steel and iron rods being first welded into bars, rolled out into rods ⅜ of an inch square, and, finally, after some intermediate processes, coiled around a mandril and welded. It would be almost impossible for a genius like Brunel to look at such an operation without seeing its adaptability to larger guns than the world had then seen.

STAYBOLTS in water-legs and other similar places of steam boilers have an almost exasperating tendency to break off without any apparent reason. Sometimes they will last for years, and again they may give way entirely within a month or two. One explanation which appears to agree very well with the facts now known was recently given in that instructive little boiler publication, *The Locomotive*, issued by the Hartford Steam Boiler Inspection and Insurance Company. According to this, there is, to begin with, a more or less relative movement between the inner and outer sheets of the furnace or water-leg, due to the variations of temperature to whi h the two are subjected. That this relative motion does take place is not only evident from the nature of the structure, but it has also been proved, experimentally, that it does occur, and a relative motion of more than a quarter of an inch has sometimes been observed. This relative motion would cause the staybolts to "rock" back and forth. If the sheets are both too thick to buckle to any sensible degree, a bending strain would be thrown upon the staybolt, which would be most severe at its two ends. The bolts would, therefore, be bent backward and forward at these points, every time the furnace sheets

moved relatively to each other, and in the course of time, after these bendings had been repeated often enough, cracks would probably start at both ends of the bolt. Even if the bending were not severe enough, in itself, to cause these cracks, it would in all probability be sufficient to keep the fibres of the iron constantly opened up to the action of the water, and the iron would be continuously oxidised at these places, so that the final result would be much the same as though the failure were due directly to the bending strains. But in actual boiler construction the fire sheet is almost invariably made considerably thinner than the outside sheet, and it may be supposed that the thin inside does buckle to some extent under the varying motions of the furnace. If such a buckling action takes place, the inner ends of the staybolts would be relieved by it of a considerable part of the bending strain that would otherwise come upon them, while the outer ends, being secured to a thicker and stiffer sheet, would be tried just as severely as before. Hence, failures should be expected to occur at the outside ends of the staybolts, and this, indeed, is the observed fact.

An excellent way of detecting these breakages consists in drilling holes into the outer ends of the bolts, and while this artifice has been in use for quite a number of years, it is by no means generally employed. It was first tried more than twenty years ago, and at that time consisted in drilling a hole about ⅛ inch in diameter centrally into the end of the staybolt for a distance of about an inch or slightly more. The bolt is, of course, weakened to some extent by this proceeding, but the loss of strength is slight. As soon as a fracture in the bolt extends inward far enough to reach the hole at any point, water will be blown out at the end of the bolt and attention will thus be called at once to the defect. The special objection which has been urged against bolts so drilled has been that, while their tensile strength is not at all seriously impaired, the hole tends to localise the bending strains at the very point where experience has shown the bolt to be weakest. Various plans have been proposed for preventing the bolts from bending locally near the outside sheet; but most of these involve an initial outlay, in building the boiler, which will probably prevent their general adoption. The form of staybolt shown in the sketch on this page, reproduced from *The Locomotive*, meets all the requirements of the case, without being too expensive for practical use. It was recommended by a committee of the Southern and Southwestern Railway



AN IMPROVED FORM OF STAY-BOLT.

Club, in these words:—"The committee believes that hollow staybolt iron should be used; that the thread should be the U. S. standard, 12 threads per inch; that the inner ends of the holes should not be opened after the stays are headed up, but that the outer ends of the holes should be kept open; that ⅞-inch stays should be turned down, between the sheets, to a scant ¾ inches." In this construction, as *The Locomotive* pointed out, there is no local weakening of the bolt, due to the hole. Such weakening as there is extends uniformly along the entire length of the bolt. The object of turning down the central portion of the bolt is to make this portion more flexible than the end of the bolt, so that when the bolt is bent by the motion of the sheets, the flexure will be distributed along the entire length of the bolt, instead of being concentrated at the outside end. Better results will probably be obtained by using larger stock, and turning down the bolt more, in proportion to its di-

ameter, than the committee has recommended in the passage cited above. In one case the staybolts of a considerable number of locomotives had given much trouble until they were replaced by others that measured 1¼ inches over the thread, and were turned down to ¾ inches in the central part. None of these new bolts have broken, although they have been in use for a considerable time.

EXPERIMENTS have lately been made at several foreign collieries with pipes varying in diameter from ¾ inch to 1½ inches to determine the conditions necessary to secure efficient speaking tubes, and also for fixing the limits of distance through which verbal communications may be made, not only between two points, but also between several points simultaneously. According to the recently published conclusions derived from these trials, it appears that the greatest distance to which a strong voice will carry distinctly through a straight tube, without branches, and in the absence of disturbing noise, is more than 1500 feet, but it cannot greatly exceed 1650 feet. There is a certain relation between the length of tube and its inside diameter, one of about 1¼ inch being suitable for a simple tube up to about 650 feet long; but above this length the diameter must increase up to 2 inches. Tubes of much more than this diameter or less than 1¼ inches are not to be recommended, and the larger the diameter, the stronger must be the voice and the clearer the articulation, words rich in vowels being transmitted more readily, and long vowels being distinguished more easily than short ones. Zinc is the best metal for a speaking tube, owing to its slight elasticity; but for signals transmitted by knocks, iron covered with zinc is preferable. A socket joint is best, because the tow used in collar joints must necessarily project into the tube, thus causing reverberations. The inside of the tubes should be as smooth as possible, while changes of diameter should be gradual, and sharp curves should be avoided. Tubes for speaking should bear upon masonry for diminishing vibration, while if they have to serve for transmitting knocks they should be hung freely, and the latter method is best for signalling to a long distance, a whistle not carrying far.

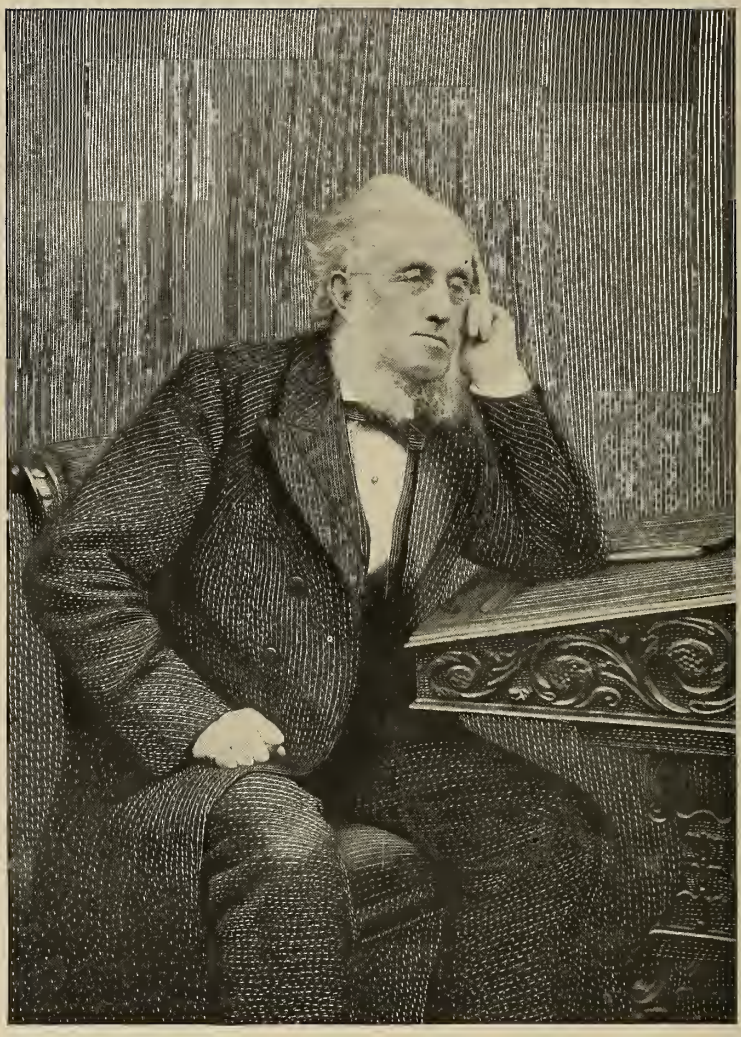
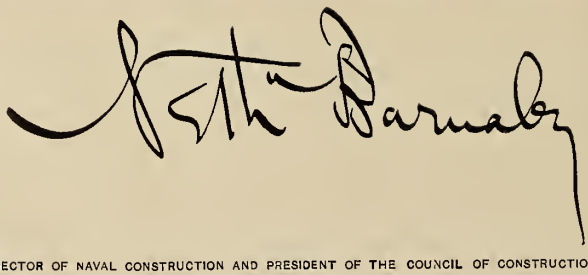


PHOTO BY MAULL & FOX, LONDON.



LATE DIRECTOR OF NAVAL CONSTRUCTION AND PRESIDENT OF THE COUNCIL OF CONSTRUCTION OF THE BRITISH NAVY.

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DIAMOND MINING IN SOUTH AFRICA.

By Thomas H. Leggett.

OF all the various kinds of mining carried on in the remote quarters of the globe, that of diamond winning is perhaps the most attractive and of the most general interest. Since the falling off in the yield from the Brazilian fields, South Africa has been the chief source of supply of these fascinating brilliants, and it was the writer's good fortune to visit the Kimberley diamond fields during the past year, and observe the various operations necessary to separate out from one ton of rock three and sixty-four one hundredths (3.64) grains of diamond.

The figures are small; the operations are enormous in scale, and as profitable as they are successful. In fact, the writer was so impressed by the extent and development of these mines at Kimberley, and the remarkably up-to-date character of their equipment and organisation, that he has endeavoured to give in the following pages an outline of their history and a sketch of the modern methods of diamond mining and "washing," or separation from the inclosing matrix.

It is a little more than thirty years ago, or in March, 1867, that the first diamond in South Africa was discovered by a Mr. John O'Reilly, who found it amongst a lot of bright pebbles lying on the table in a farmhouse in the Hopetown district.

This district is just south of the Orange river, and as soon as the fact was established that the diamond came, not from that, but from the Vaal river, the first rush of diggers to the banks of the latter stream took place; hence it was not until 1870 that the true source of the diamond was found by the discovery of several at Dutoitspan, fourteen miles south of the Vaal river.

The river-diggings are now practically abandoned, but they furnished a number of very pure stones during those years, the largest of which was the "Star of South Africa," weighing 83½ carats when uncut. This stone first changed hands for £400, then for £12,000, and ultimately was purchased by Lord Dudley.

The discovery of the Dutoitspan mine caused an immediate rush to that farm, now marked by the town of Beaconsfield, a suburb of Kimberley. The latter town, named in compliment to Lord Kimberley, the then British Secretary for the Colonies, lies at an elevation of 4050 feet above sea level, in latitude

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AT THE 1000-FOOT LEVEL IN THE KIMBERLEY MINE.

28° 42′ south, or 650 miles north of Cape Town, with which it is connected by rail.

It is an oasis in the South African Karoo, with well-paved, tree-lined streets, substantially built stone and brick buildings, pretty residences, a most comfortable club, and an excellent water supply from the Vaal river. The water is brought in through a pipe line, 18 miles long, and was installed at great expense before the advent of the railway, with the object of supplying not only the town, but the diamond-washing machines of the various mines. The town is built up to the very edges of the huge, crater-like excavations of the Kimberley and De Beers mines, which are the two principal ones now working. The Dutoitspan and the Bulfontein mines lie two miles to the south, near Beaconsfield, and were closed down at the time of the amalgamation of these properties with the De Beers consolidated mines in 1890.

A small portion of the Bulfontein deposit, not included in this amalgamation of interests, is being worked today by the New Bulfontein and Standard companies, and the De Beers Company have recently started the famous Wesselton (formerly the Premier) mine, lying three miles southeast of Kimberley and close to the border of the Orange Free State, while the Kamfersdam mine is another late addition to the diamond producers of the district.

Before describing the methods of winning these precious stones, a glance at the geology and history of the district will be of interest. The Kimberley diamond mines occur in the Kimberley-shales of the Lower Karoo beds. The shales and sandstones of the Upper Karoo beds constitute the widely known "Karoo," or dry-lands, forming so large a part of that section of the Orange Free State and Northern Cape Colony.

Below the first mentioned strata lie the Ecca beds of sandy clay and quartzitic sandstones, and beneath these the Dwyka conglomerate, which forms the base of the Karoo system and rests uncomfortably upon the older Cape formation. The Karoo system is assigned by A. C. Seward, Esq., F. G. S., who has recently examined plant fossils from it, to the close of the Paleozoic and beginning of the Mesozoic ages. Its upper beds carry the coal measures of Johannesburg and the Transvaal.

The Cape system lies between the Karoo system and the Archæan rocks forming the base of the continent, and includes, among its five chief beds, the Table Mountain slates and sandstones of Cape Town, and in the Transvaal the quartzitic sandstones which carry the gold-bearing banket (pudding-stone) reefs of Johannesburg.

FIRST METHOD OF WORKING, BY ROADWAYS ACROSS THE MINE, 1872.

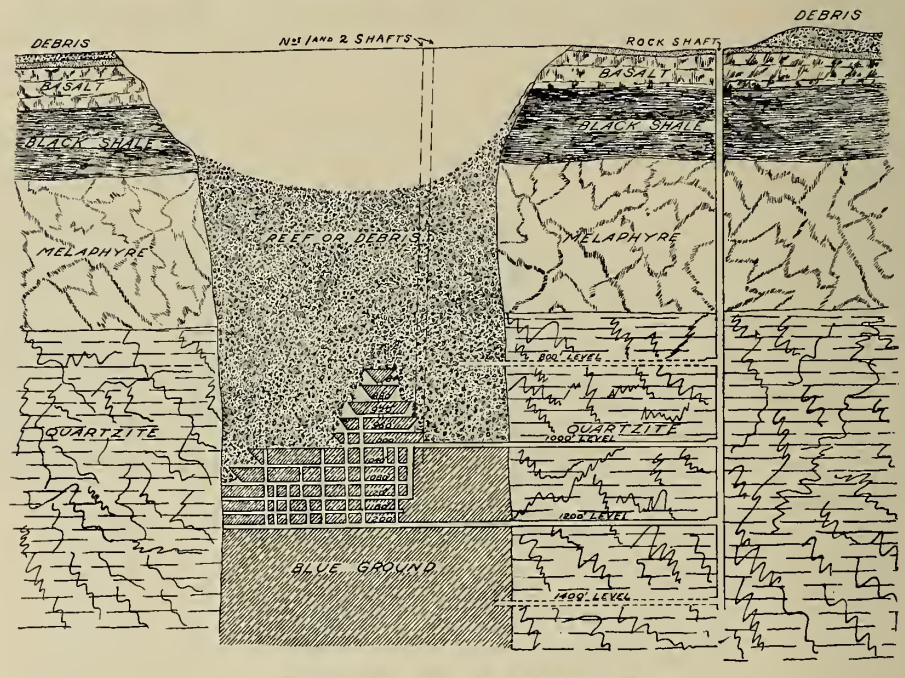
The rock in which the diamonds occur is of eruptive origin, and has burst through the overlying quartzites, shales, and interbedded igneous rock, spreading out into a funnel-shape at the surface. The theories regarding the origin of this deposit do not come within the scope of this article, but it may be mentioned that the contemporaneity of deposition of the matrix and the diamond is now generally accepted.

The section through the De Beers mine on the next page gives an excellent idea of how these "pipes," or chimneys, of diamondiferous rock occur, and of the strata through which they have penetrated to the surface. The

Kimberley black shale lies between basalt and melaphyre and contains such quantities of carbonaceous matter and pyrites as oftentimes to ignite after exposure to the air, and to burn continuously with the emission of sulphurous fumes.

Regarding any reported discovery of a new diamond mine, one of the first questions asked is, "Is it a pipe?" because if so, there is every reason to be assured of its permanency. These "pipes" are roughly circular or elliptical in section, and several hundred feet, sometimes one thousand feet, years past, is the hard, unoxidised and unhydrated diamond-bearing rock of the general tone of colour indicated by its name. It requires drilling and blasting, like any other hard rock, but the impression that diamonds are thereby crushed and broken is erroneous. Their fracture is more often due to passage through the fine rolls in the washing operations rather than to blasting. Upon exposure to air this rock changes to a gray colour, and disintegrates and crumbles, especially after moistening with water.

To this fortunate characteristic is due



A SECTION THROUGH THE DE BEERS MINE.

across. Contrary to the once common belief, there is very seldom a basin-like depression or other change in the surface topography to indicate their existence.

The ground forming the top of the "pipe" is, for about the first thirty yards in depth, usually of a light yellow colour, due to the decomposition of the "Kimberlite," or diamondiferous rock, and is called "yellow ground." "Blue ground," in which the Kimberley and De Beers mines have been working for the existence of the extensive "floors" at Kimberley containing millions of tons of blue ground in all degrees of weathering. The matrix of this rock, although difficult to determine, is generally conceded to be a serpentine, and the chief minerals imbedded in it, in addition to the diamond, are garnet, olivine, mica, carbon (ilmenite), calcite, zircon, magnetite and occasional iron pyrite. Sometimes splints and fragments of black slate are also found in it.

Dykes of igneous rock, non-diamond-

AFTER TAKING OUT THE ROADWAYS, 1873.

iferous, are occasionally encountered within the limits of the "pipe," and, nearer the surface, huge boulders of the same and isolated masses of shale are sometimes found. These fall into the mine with the "reef," as is called the surrounding basalt and shales, forming the *débris* at the bottom of the present huge excavations.

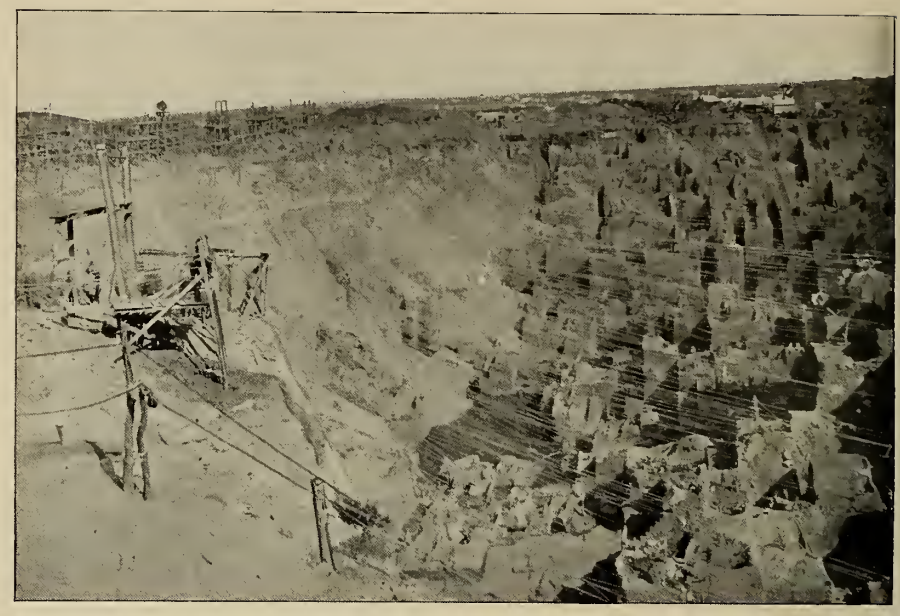
Mining claims in Kimberley are now thirty Cape Feet square (about thirty-one feet English), and according to the first law for the regulation of diamond mining in 1870, no party claims could exceed six in number. A miner was allowed to locate two claims for which he paid to the Cape government a monthly license of ten shillings each, and the present mines are held under similar tenure.

The early law was based upon the principle of the greatest good for the greatest number, which was very well so long as the mines were shallow, although even then many disputes arose through one owner's ground caving in upon the deeper neighbouring claims and from similar causes.

The size of the claims permitted of several hundred owners upon a single mine, and the first attempt at systematic working was the leaving of roadways fifteen feet in width across the mine, as shown on page 373. It was soon found, however, that these could not be safely maintained. They were, therefore, abandoned, and stagings were erected around the rim of the excavation by means of which the material was handled by wire rope and bucket.

As greater depth was attained, these were found to be insufficient, and were replaced by heavier buckets, suspended from a car or trolley, traveling on well-anchored carrying ropes. Sometimes, in place of a bucket, the car bodies with their contents were picked off their trucks and brought to the surface. Even this method soon reached its limits in consequence of the repeated heavy falls of reef, or shales and basalt forming the rim of the pipe, which often stopped the work of hoisting the blue ground for months at a time.

An idea of the magnitude of this work of removing worthless over-burden may be gained from the statement of the general manager, Mr. Gardner F. Williams, who has brought these mines to their present wonderful stage of develop-



STILL DEEPER. WORKING WITH TRAVELLING BUCKETS. THE HONEYCOMBED APPEARANCE IS DUE TO THE DIFFERENT DEPTHS OF THE VARIOUS OWNERS' CLAIMS.

ment, and who foresaw the requirements when he said, in 1886, that "the future success of the Kimberley mines depends upon the adoption of a systematic and economic plan of underground mining through shafts sunk outside the disturbed area." Up to May 1, 1883, 10,325,989 "loads" of 16 cubic feet each had been removed from the Kimberley mine alone, equivalent to 3,824,440 cubic yards of solid rock, at a cost of £1, 545,358. This is at the rate of 3s. per load, or 8s., 1.5d. per cubic yard.

In 1883, 1,688,914 loads of reef were removed, and in 1884, 711,033 loads, from this one mine, and still it was impossible to uncover the blue ground as fast as it was being buried under the constantly recurring slides of rock from the sides of the excavation.

The De Beers mines profited by the experience of the then richer Kimberley mine, and, earlier in its history, abandoned all surface working. In some instances cribbed shafts were sunk through the overlying *débris*, allowing a certain amount of mining being done without a heavy initial outlay; but practically all such work was abandoned in 1886, and in the succeeding year in favour of underground mining through vertical shafts and cross-cuts. In no case were the open workings carried to a greater depth than 400 feet. To-day all the blue ground from the Kimberley mine is hoisted from the 1520-foot level, while that from the De Beers mine comes from the 1200-foot level.

In the Kimberley shaft the stations are cut, and cross-cuts are driven, every 320 feet, which allows of just eight working levels in the mine, 40 feet apart. Work was carried on at the 1200-foot level for about two and a half years before changing to the deeper level.

In the De Beers mine, on account of its greater area, the stations and cross-cuts are located only 200 feet apart, admitting of five working levels, 40 feet apart, in the mine proper. Hoisting was carried on from the 1000-foot level for three and a half years before changing to the next deeper one at 1200 feet. These shafts and cross-cuts are now, and have been for years past, entirely in the hard quartzitic sandstones, the

thickness of which is as yet unknown.

That the "pipes" of "Kimberlite," as this diamond-bearing rock is called by mineralogists, are not always vertical, is indicated by the fact that in the De Beers mine, at the 1000-foot level, the main cross-cut is about 800 feet long; it is 900 feet long at the 1200-foot level, and is estimated to be 1000 feet long at the 1400-foot level unless the pipe-walls change their present dip. These walls, however, remain approximately parallel, so that, with increased depth, the reduction in area of cross-section has thus far been but little.

All of the De Beers pipe is not being broken "Kimberlite," weighing 16 cwt., or eight-tenths of a ton. When ore-cars were introduced, they were made of the same convenient capacity, and cars of this size are used underground to this day, the output being measured in terms of this unit.

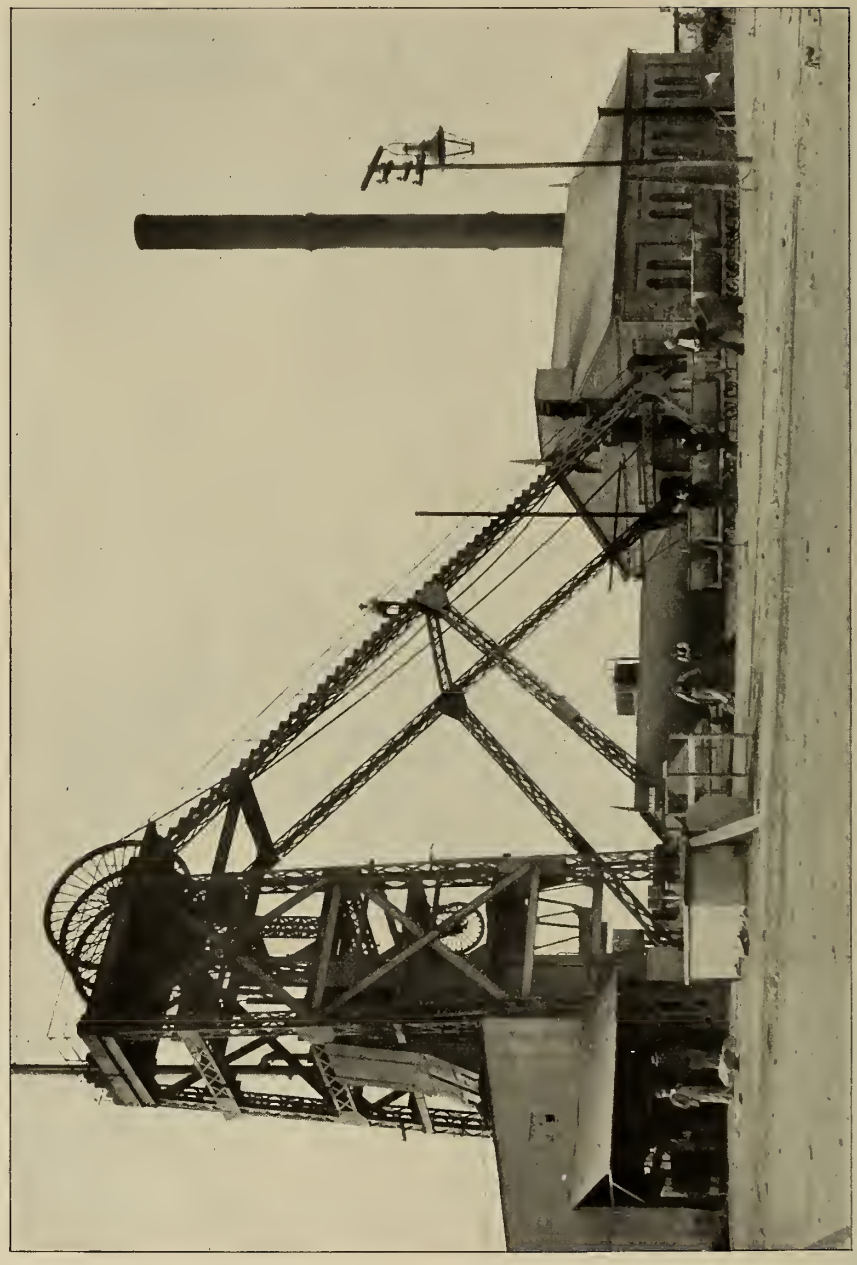
As already stated, the working levels in the mine are 40 feet apart, and upon each of these levels two or more main drives are driven across the pipe to the opposite wall, at varying distances of from 60 to 120 feet apart. These are connected by a main cross-drive near their ends, and perhaps two or more intermediate ones.

Beginning at the ends of these drives

OPEN WORKINGS ABANDONED AND ALL WORK DONE UNDERGROUND THROUGH VERTICAL SHAFTS. RIM-ROCK, SHOWING SHALES UNDERNEATH.

mined to-day in consequence of the lower value of a part, averaging but about one-half a carat per load as against nine-tenths of a carat from the portion now working. This value is still payable, and unquestionably this ground will all be extracted at some future day.

A word here, in explanation of the term "load," which is the unit of measurement in all South African diamond mining. It originated by the use in the early days of the ordinary dump-cart, or Scotch-cart, as it is called there, having a capacity of 16 cubic feet of loose or furthest from the main cross-cuts, drifts or off-sets are driven to the rim-rock at distances apart of 22½ feet from centre to centre. These are widened out into chambers leaving a pillar between them, and stoping is carried out in the roof, the Kafir drill-boys standing on the broken ground of previous blasts, until breaking through into the level above where lies the reef or *débris* that has followed down from the open workings. The ground between the main drives is pierced by small drives, which are widened into chambers in the same way.



STEEL HEADGEAR AT THE MAIN SHAFT OF THE KIMBERLEY MINE.

The pillars on the sides of the chamber are then blasted down, the workmen receding towards the main drives until the entire level is worked out.

When reef breaks through the roof of a chamber, it, of course, carries with it the blue ground remaining in that roof. This falls on the chamber floor and is drawn away until the *débris* proper appears, when what remains is left to be carried to the next level. Hence, when a chamber-roof breaks down it is always broken blue ground that appears first, and it is usually a number of days before any of the reef shows.

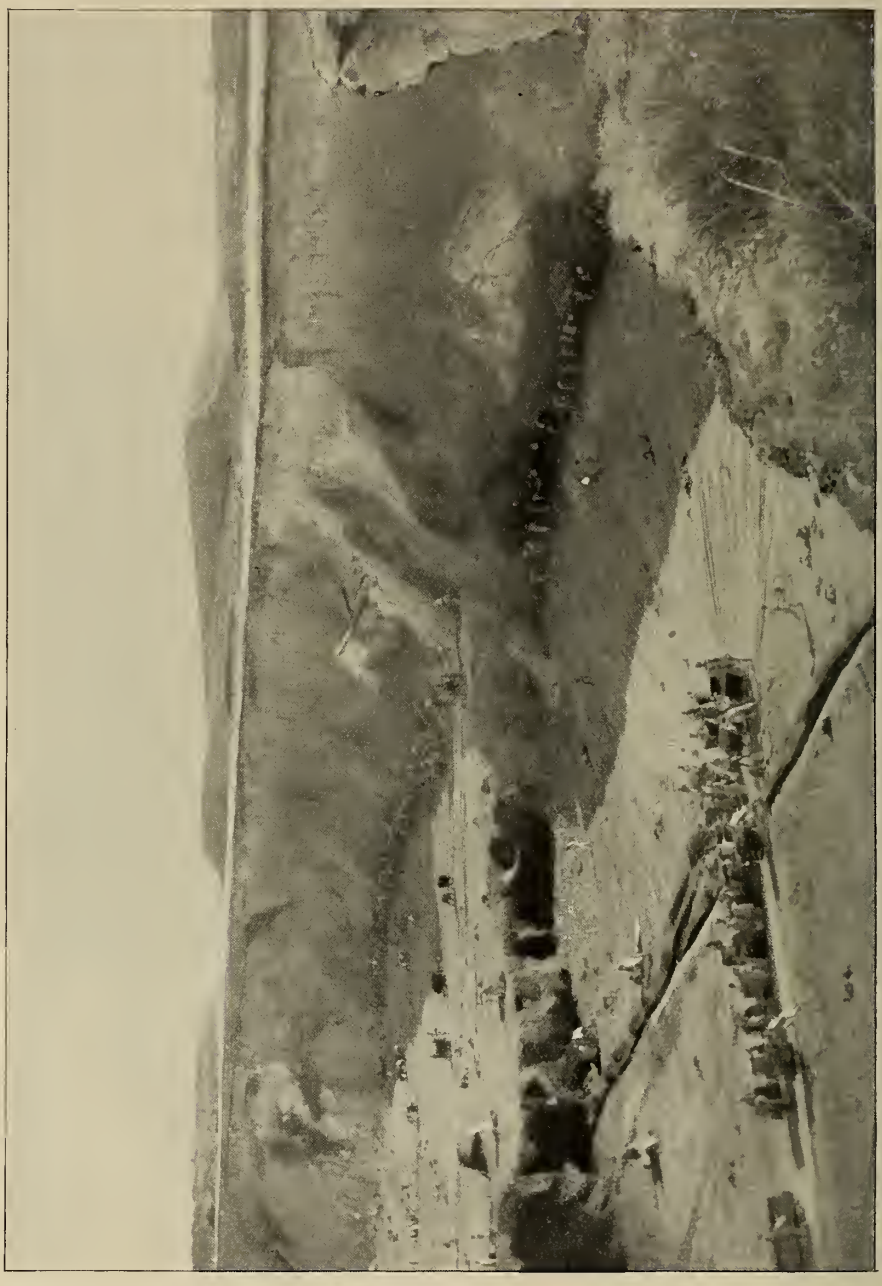
An idea of the amount of work done in the De Beers mine in one fortnight (12 working days) may be obtained from the following figures:—During the first two weeks in November, 1897, there were used 8¾ tons of dynamite, 65,100 feet of fuse (equal to 12⅓ miles), and 32,500 blasting-caps, and during the previous month the record hoisting was made of 182,040 loads, or 145,632 tons, through one shaft, and from the 1200 foot level.

The ventilation in these mines is good, as both maintain connection with old shafts, by means of which, in the De Beers mine, there is obtained a natural current of 57,000 cubic feet of air per minute. In spite of this, however, the faces of the stopes or chambers are unavoidably hot.

The Kafir "boys," as they are termed, do not at all object to this atmosphere. They are worked in gangs of thirty or forty, under the direction of a white miner, or boss, and become fairly proficient in all the work of drilling, blasting, tramming, handling the ore-chutes, etc., and very much at home underground.

But the one thing that will make a Kafir literally turn pale is the sound of the fatal mud-rush. In these mines at any given time there will be four or five levels upon which mining is being car-

MODERN METHOD OF OPEN WORKING IN THE PREMIER, OR WESSELTON, MINE, 1897. TAKING OUT THE SECOND CUT, 65 FEET HIGH, AFTER WHICH THE MINING WILL BE CARRIED ON UNDERGROUND.



ANOTHER VIEW OF THE WESSELTON MINE.

ried on, all more or less open to the overlying *débris*, or reef, which is continually filling in the space once occupied by the diamond-bearing rock. The old surface workings of the De Beers and Kimberley mines are from 30 to 40 acres in extent, several hundred feet deep, and, of course, open to the rainfall, which averages about 17½ inches per year. In addition to this, water is continually draining into these huge excavations and seeping into the mine below from unknown sources in the surrounding rocks.

Where this accumulates in the overlying *débris*, it makes a muddy mass, of the consistency of thick paste, carrying boulders and rocks in it, and when this breaks through the roof of a chamber it rushes with irresistible force and velocity for hundreds of feet into the drives and down the ore-passes or chutes, carrying all before it. The writer has seen evidences of this force in twisted rails, collapsed cars, and broken 12-inch timbers strewn along a drive.

The mud rushes occur with more or less frequency, especially in the De Beers mine, and give little or no premonitory warning. One that occurred in June, 1897, imprisoned two Kafirs, who were rescued after twenty-eight hours by two courageous white miners, and most fortunately so, since the next day another rush took place in the same locality, refilling some of the already partially cleared workings. The danger from these mud-rushes is great, and the loss of life is often serious.

Regarding the measures being taken to prevent these occurrences Mr. Gardner F. Williams, in his last annual report, says:—"I feel confident that, in time, we will be able to overcome them, and to this end the following work is being carried out:—We are driving a tunnel around the mine at the hard rock level, about 380 feet from the surface, in order to take up the water which flows into the open mine below the shale. Tunnels are being driven on the 1000-foot level on the south and east sides of the mine, which will be continued until they meet. We now propose to get a diamond drill and make holes between levels, with a view of tapping the water. Everything is being, and will be, done to bring about the same condition of things in De Beers as in Kimberley mine.

"The problems are not the same, however, for in Kimberley mine the *débris* had followed down as the blue ground was extracted, and had left the hard rock (melaphyre) exposed to view, and we could see where the streams of water flowed into the open mine; but in De Beers no hard rock has yet been exposed, and we have to grope in the dark, as it were, to find out where the water enters the open or worked-out portions of the mine."

The 800-foot level is the top level in the De Beers mine to-day, and all the rock mined between this and the 1200-foot level is shot down through winzes, or ore-passes, to the latter level and there carried in cars by mechanical haulage through the long double track cross-cut to the loading station at the shaft. The cars come in thick and fast at the station, oftentimes only a few feet apart, and it is an interesting sight to watch the rapidity with which they are released from the rope, dumped and returned to it, by the Kafirs trained to this work.

The main shaft at each mine is of four compartments, two of which are devoted to the hoisting of the diamondiferous rock; one is fitted with the ordinary double-deck cage for hauling men and tools by a separate hoisting engine; and the fourth is occupied by the Cornish pumps and ladder-ways.

The amount of water pumped is not now great, amounting in 1897 to 4350 gallons per hour from the De Beers mine and about double that quantity from the Kimberley. In previous years, however, it has been, at times, nearly twice these amounts.

Hoisting of the blue ground at the De Beers shaft is done in heavy, vertical-type skips, weighing about 2½ tons, and carrying 6 loads, or 4.8 tons, each. The loading chute at the bins holds just this quantity, and it is delivered by a specially designed Seymour-gate at once

into the skip, consuming from three to five seconds in the operation.

The hoisting is always done in balance, and at the shaft mentioned the work is done by a horizontal, direct-acting compound engine, cylinders 26 inches and 40 inches, by 60 inches, drum 10 feet in diameter by 12 feet face, with no centre division and no centre bearing. When the most rapid hoisting is being done, the piston speed of this engine has reached 1200 feet per minute.

The record hoisting at the De Beers shaft has been made from the deepest (1200-foot) level, and up to November 16, 1897, this record stood for a single eight-hour shift, 3452 loads, or 2761 tons; and for twenty-four hours, 8702 loads, or 6961.6 tons. This is equivalent to 4.83 tons, or just one skip-load per minute, for every minute of the 24 hours. Of course, many of the trips were made in very considerably less than one minute, but the above is the average. The writer believes himself well within the mark in saying that nowhere else in the world is such a tonnage hoisted from such a depth in the same time.

At the Kimberley mine shaft a vertical-type hoisting engine has been converted to the Whiting system of hoist, which system was used first at the Calumet and Hecla copper mine in Lake Superior, and is now introduced at several deep-level shafts on the Rand. The grooved wheel or drum on the crank shaft of this engine having cracked, a new one was made at Kimberley to replace it, and it was the writer's good fortune to witness the casting of this 10-ton wheel in the company's foundry. The incident is mentioned as illustrative of the development of the foundry and machine shops of this enormous concern.

ONE OF THE DEPOSITING "FLOORS" OF THE DE BEERS DIAMOND MINE, SHOWING LUMPS OF THE MORE REFRACTORY "HARD BLUE." TAILINGS HEAPS FROM THE WASHING PLANTS ARE SHOWN IN THE BACKGROUND.

A skip of 4 tons capacity is there used, and the record hoisting for 12 hours stood at 4675 loads, or 3740 tons, from the 1520-foot level. The writer watched one trip, made from that level at the usual speed, and made the time, including filling and dumping of the skip, to be forty-two seconds.

As every skip at the De Beers shaft

A DEPOSITING FLOOR AFTER HARROWING.

discharges six carloads at a time into the head-gear bins, and as these latter are necessarily very limited in capacity, most rapid loading of the surface cars is required in order that the hoisting may be uninterrupted.

This was made possible only by filling the cars over an open grating, with a bin sunk in the ground beneath to catch the spill from each car as it filled, thereby preventing the clogging of the track. This bin is emptied whenever there is a slight cessation in the regular hoisting, the cars being raised to ground level and run on to the mechanical haulage rope. The latter is driven by a 150 H. P. engine, and the cars are now taken a distance of quite four miles to the furthest depositing floors.

Wire rope is used in all the haulages of the De Beers Company, and is attached to the car by means of a V-shaped jockey on the top of the car body. Rope is preferred to chain, as, being lighter, the jockeys can stand several inches higher above the car body, allowing the latter to be loaded fuller. As the contractors are paid by the car, this is an item on thousands of cars per day.

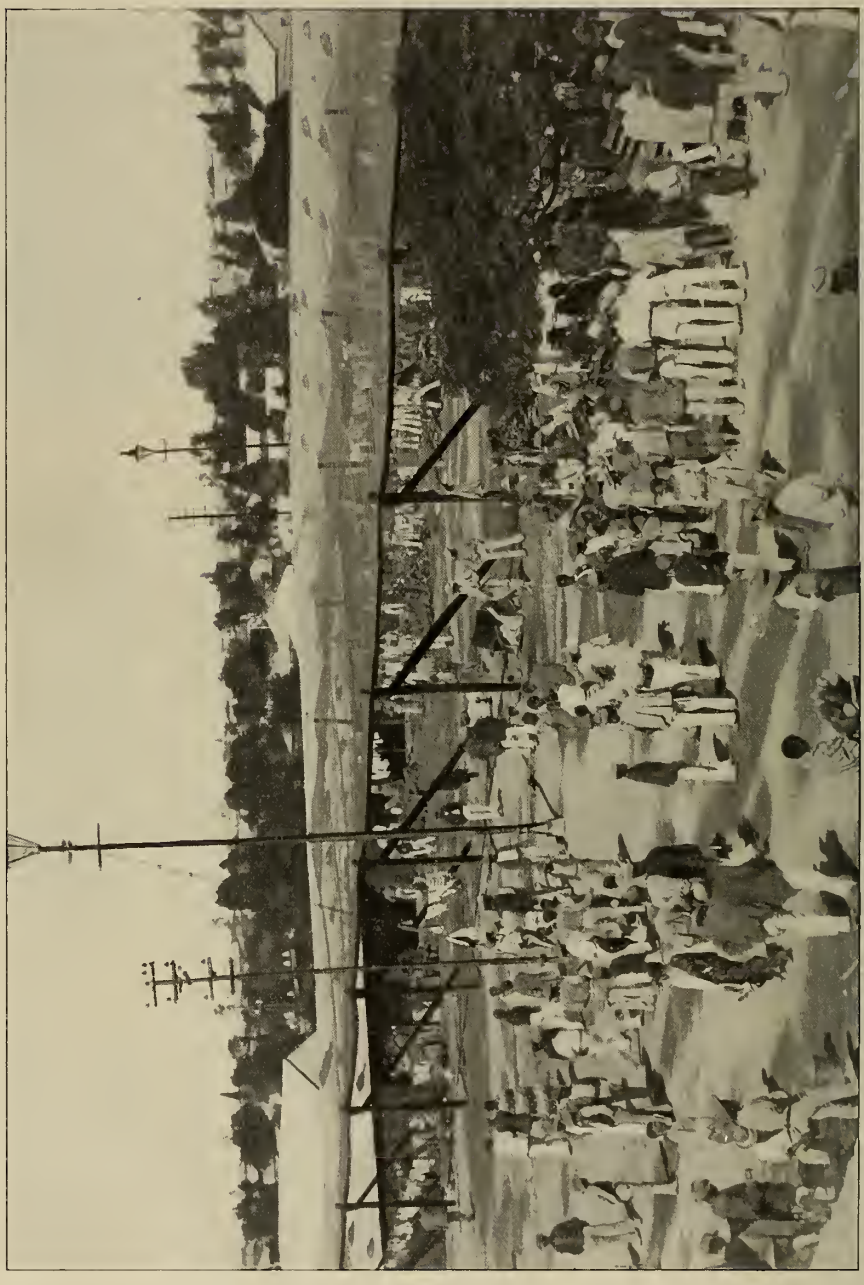
The average speed of the haulage is 4 to 4½ miles per hour, and the maximum speed 5 miles. Forty-five-pound rails are used on the main tracks, and twenty-pound rails on the subsidiary tracks. Upon the latter three cars are hauled by one mule, the light track being shifted as the floors fill up.

The auxiliary haulages divide the floors into spaces, 400 yards by 200 yards, and on these the blue ground is deposited for a depth of about 10 inches. The only treatment to which the flat "veldt," or prairie land, is subjected previous to receiving the Kimberlite, is to be stripped of grass, bush, and any loose stones. Formerly it was rolled hard and smooth, but this is not now done.

The first operation the Kimberlite undergoes is that of harrowing. the harrows being drawn back and forth between two traction engines, stationed several hundred yards apart, thus avoiding the packing that would take place if the blue ground were traveled over by a steam harrow. After a proper interval, the next process is that of winnowing, or collecting the lumps of hard "blue" that will not disintegrate into heaps. Portable tracks are laid down and the lumps are sent to the crusher house.

A second harrowing then takes place, and if no rains have set in, the deposited ground is wet by hose, a complete system of water-pipe being laid over the "floors" for this purpose.

After another interval, to allow of further weathering taking place, the



THE DE BEERS COMPOUND. THE QUARTERS OF THE KAFIR LABOURERS.

material is loaded into cars on movable tracks, run to the main haulage and sent to the washing machines, any remaining pieces of hard "blue" being stacked separately and sent to the crushing and concentrating mill. The floor is then ready for a fresh deposit from the mines.

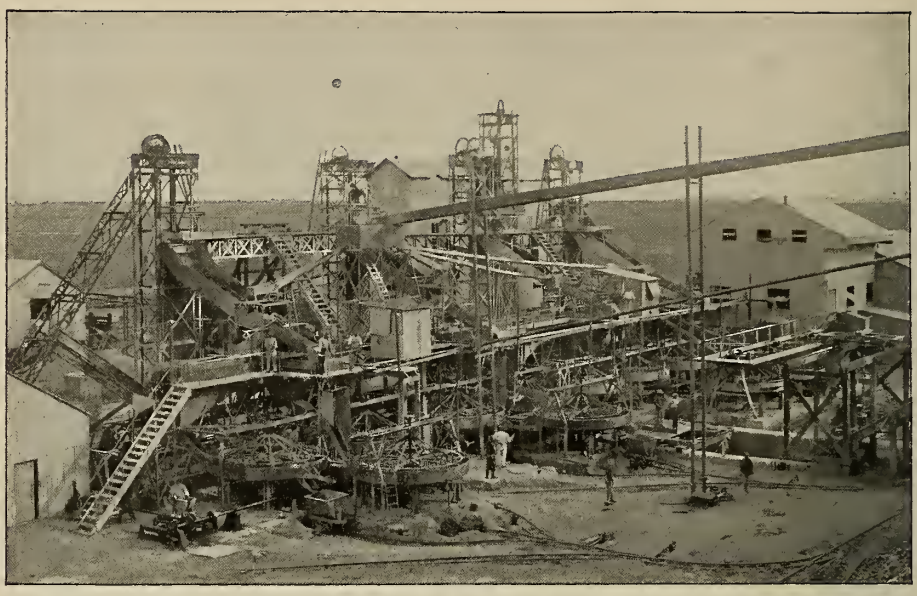
The entire cycle of operations takes about a year for the De Beers blue ground, sometimes less than this when rains are more frequent. The Kimberley blue ground disintegrates in half that time. The floors are fenced about with barbed wire fencing, and are continually under guard, the night watch being aided by a system of well-arranged arc lights.

On July 1, 1897, there were lying upon the depositing floors of the Kimberley, De Beers and the newly started Wesselton mine an amount of 2,576,694 loads of diamond rock, equal to 2,061,355 tons. At a moderate estimate this tonnage contains over £3,000,000 worth of diamonds, and it also represents a very large amount of capital invested in the mining and transportation of the material.

Smaller companies, such as those at work on certain claims in the Bulfontein mines, endeavour to avoid this locking up of capital and postponement of revenue by treating the blue ground direct from the mine, without the preliminary exposure on floors, but it is a moot question whether this method is as good in point of diamond recovery. Its advantages from a financial standpoint are evident, but the method has not found favour with the De Beers experts in diamond washing

DIVING FOR SILVER PIECES IN THE SWIMMING TANK IN THE COMPOUND.

It is an essential requisite of the latter operation that the pulp in the pans shall be of a certain consistency, about one-third of its bulk being formed of fine mud. It is argued that if the ground is first weathered on the floors,



ONE OF THE WASHING PLANTS FOR "BLUE GROUND," SOFTENED BY EXPOSURE ON THE "FLOORS."

as described above, it will furnish enough fine dirt to form the desired thickness of pulp in the washing-pans. On the other hand, if taken direct from the mine to the rolls, screens and washing-pans, the proper consistency of pulp cannot be obtained without returning into the pan a certain proportion of diamondless fine mud or "puddle" from the tailings discharge; in fact, the writer saw this being done at one of these newer washing plants.

This retreatment of worthless material means a considerable reduction in the capacity of the plant; at the same time, it is not proven that it may not pay better to increase this capacity even by 20 per cent. or 25 per cent., rather than incur the delay and expense of floor depositing, especially for a new company just starting operations. The cost of floor depositing is about 5 cents (2½d.) per load, while adding the expense of haulage to and from the floors would probably treble this figure.

It is not likely that in the case of the "direct crushing" of the blue, the interest on the additional capital needed for larger plant, plus depreciation and slightly increased running expense, would equal this charge; but there are, of course, other matters to be taken into consideration in comparing the two methods, and all that can be said from the data at hand is that direct crushing seems worthy of thorough investigation and trial. If successful, it would prove especially applicable to the recently discovered pipes of diamondiferous rock (so claimed) northeast of Pretoria in the Transvaal, in which the blue ground comes within a few feet of the surface and is unusually hard and tenacious.

The various washing plants differ somewhat in detail, while the general method of treatment is alike in all. The plant at the Kamfersdam mine has been recently erected, has a capacity of 4000 loads per day, and is a good illustration of the general process adopted.

The entire plant is driven by two Fleming & Ferguson triangular connecting-rod engines, of the vertical type, using quadruple expansion, and of 500 H. P. each. The material is elevated and delivered on grizzly bars, spaced three inches apart. The coarse material is delivered into eight Comet crushers, set in pairs, whence the fines and the crushed rock

are fed, together with water, into a double set of rolls, each 4 feet diameter by 2½ feet corrugated face. These run at 45 revolutions per minute, and are set, the upper ones 1¾″ apart, and the lower ones ⅞″. They weigh about 30 tons, and take about 60 H. P. to drive. From the rolls the muddy pulp is elevated and discharged into trommels, or revolving screens.

The elevators are fitted with manganese steel buckets, carried on steel chains, and run at a speed of 60 feet per minute, lifting the material about 30 feet. The trommels are pierced with

The upper pans have flat bottoms, while the safety pan bottoms slope slightly toward the outer rim. They are fitted with stirring-arms driven from a common centre shaft at a speed of 8 to 9 revolutions per minute, the stirrers being set to follow a spiral path, thus gradually forcing the material to the outer edge of the pan. One pan washes from 300 to 400 loads per day of ten hours. None of these plants work at night in order to avoid the danger of loss by theft.

The tailings overflow is at the inside rim of the pan; hence the diamonds

CRUSHING AND CONCENTRATING MILL FOR REFRACTORY "HARD BLUE," AT THE DE BEERS MINE, DRIVEN BY A 1100 H. P. COMPOUND VERTICAL ENGINE.

¾-inch holes, and everything passing through them goes into the upper row of eight washing-pans, while all material larger than that diameter is carried to the fine rolls together with the overflow from these pans. These rolls are 6 feet in diameter by 2½ feet face, and are set 3-16 inch apart, and all pulp from them is delivered by bucket-elevator to the second or lower row of eight safety pans. The washing-pans, both upper and lower, are annular in shape, 14 feet in outer diameter and 4 feet inner diameter, the outer rim being 12 inches high and the inner one about 8 inches.

and heavier minerals are gradually collected in the bottom of the last or safety-pan, whence they are periodically withdrawn through a slide door extending across the bottom of the pan, and discharged either into a locked iron car, or, if the pulsator house be close by, into a closed mechanical conveyor of some description, usually of the trough or the bucket type.

The De Beers Consolidated Mines, Limited, have, in the various washing plants of the three mines already mentioned, a total of fifty-five of these pans in operation. Some of the washing plants, such as the new one at the

FIRST SORTING OF THE JIG CONCENTRATES FOR DIAMONDS BY WHITE LABOUR

Wesselton mine, do away with safety-pans, washing entirely in one set; but in this plant there are no crushers, the coarse rock from the trommels passing through a double set of rolls, the lower being ½" to ⅜" apart, whence the material is delivered to what are known as the "lump pans," where the proper thickness of puddle is obtained by returning fine mud or pulp from the tailings discharge.

Thousands of tons of tailings in the shape of mud and gravel from which the diamonds have been extracted are discharged daily, and it has been found that the cheapest method of handling these is by means of two skips on an inclined track running to the top of the dump.

The skips are made very large, the usual capacity being 120 cubic feet of mud and water. The maintenance of these costs very much less than that of a bucket elevator, while the roadway can be carried up to any height, whereas the elevator soon reaches its economical limit in that direction.

The huge concentrating mill, of which an illustration is given on page 387, treats the lumps of "hard blue" that have remained intact after the ordinary exposure and treatment on the floors, and also the trommel-lumps from such of the De Beers washing plants as are not fitted with crushers, these lumps being about half hard blue, that would never disintegrate.

The rock is first reduced by Comet crushers to a two-inch size, and before passing to the rolls, the coarse material coming from the trommels below these crushers is delivered onto circular sorting tables in order that no large diamonds shall be crushed. Thus far, no diamonds of any consequence have been picked out on these tables. Following them is a series of rolls, trommels and jigs such as may be seen in any concentrating mill, the prevailing jig sizes being ⅝-inch, ½-inch, ⅜-inch, ¼-inch, and ⅛-inch. In each case the hutch product is reduced by rolls and passed to the smaller size jigs.

The illustration on page 387 shows the building divided into two sections, the nearer of which is termed the "finishing" mill, containing the finer rolls and jigs, and between it and the "crushing" mill is a huge bucket elevator necessary for hoisting the material from the latter section. Mr. G. W. Labram, the mechanical engineer of the company, furnishes the following description of this elevator:—

"The top and bottom wheel-shafts are 6 inches in diameter, and 52 feet between centres, the top shaft carrying two horn-wheels of 12 teeth for 9-inch-pitch chain. The buckets are 4 feet long, holding about 5 cubic feet, are spaced 3 feet apart, and travel about 80 feet per minute. The material handled is from ⅞-inch ring to fines, and the amount lifted is from 100 to 140 tons per hour, together with water enough to fill the buckets."

This mill treats about 900 tons per day, and sends to the pulsator house for final screening and jigging a little less than 1 per cent. of that amount, or 8 to 9 tons. The pulsator house is the local name of a small sizing and jigging mill, that treats the diamond-bearing gravel from the washing-pans, and from the crushing and concentrating mill.

This material is delivered into a revolving trommel, having four round-hole screen sizes, viz., ⅛-inch, 3-16-inch, ¼-inch and ⅜-inch. Everything larger than ⅜-inch passes out the end of the screen and is hand-sorted. Mineral smaller than ⅛-inch passes over an outer jacket-screen, pierced with 1-16-inch holes, and all grains passing through this are discarded, from which one infers that diamonds of less than this diameter are not worth saving.

The sized material from the screens passes to jigs of corresponding mesh, the jigging being done through a bed of lead bullets to prevent the material from passing through too rapidly. The jig overflow is run to waste and the hutch product is sent to the sorting house.

Of the 1 per cent. of the original blue ground received into the pulsator house about seven-eighths is discarded, or, in other words, every 100 tons of diamond rock mined is concentrated to from 250

UNCUT DIAMONDS AS THEY COME FROM THE SORTING HOUSE. THE LARGE STONE IS FULL SIZE. IT WEIGHED 428½ CARATS AS PHOTOGRAPHED, AND 228½ CARATS AFTER CUTTING.

to 300 pounds of fine gravel, containing all the diamonds of the original quantity and from which they have to be extracted by hand-sorting. Very recently, however, experiments have been made by Mr. Kirsten and Mr. Labram with a light side-shaking table, covered with grease of a particular composition, from which they have obtained excellent results, it being found that the diamonds adhere, while all the other minerals are washed over into the discharge. The diamonds are separated from the grease by melting the latter, when they sink to the bottom of the vessel.

The idea arose from noting the adhesion of diamonds to any grease that might fall into the washing-pans from off the gear-wheels, and it promises to prove of great practical utility, as such a machine will do away with the labour of thirty boys. The first test of the table was made with the finest sand-size of mineral from the pulsator house; out of 6601 carats contained in the mineral, there were lost 111, or 1.7 per cent.

The second test was made on coarser material, from 3-16-inch to ⅜-inch in size, and out of 19,031 carats passed over the table only 40¼ carats were lost, or one-fifth of one per cent. From these tests, it would seem

that the table saves the larger diamonds more effectually than the fine ones.

The wet diamond-bearing gravel is a pretty sight as it lies in heaps on the sorting tables. One has to look long and closely to find a diamond, but the red garnets, the brilliant green, glassy fragments of olivine, and the light yellow zircons sparkle brightly among the black grains of magnetite and other dark minerals.

The sorted diamonds are washed in acid (sulphuric and nitric) before being taken to the valuator's department, where they are classified for shipment.

Kimberley mines, put out 2,769,423 carats, equal to 1254.3 pounds (Avoirdupois), or, roughly, five-eighths of a ton of diamonds obtained from washing 2,409,030 tons of diamond-bearing rock. At no time since 1890 has the yearly product been less than 900 pounds (Avoirdupois) of diamonds, while it has reached as high as the figure given above.

It is evident, therefore, that the consolidation of the majority of the Kimberley diamond mining interests was as necessary from a financial standpoint as from a mining point of view. It was

SECOND SORTING OF THE JIG CONCENTRATES FOR DIAMONDS BY CONVICT LABOUR.

Deep, pronounced tints of pink, brown, and yellow are called "fancy stones," and are of increased value, while the lighter shades of colour detract from the value as compared with the colourless diamond. This work of classification of the uncut gems requires the eye of an expert, as indicated by the great number of parcels in a single shipment lot, each parcel representing a different shade of colour, and, hence, a different value.

For the year ending June 30, 1897, the De Beers Consolidated Mines, Limited, working only the De Beers and

impossible to continue mining in the "open" and with a hundred or more different owners on a single mine or "pipe;" it was equally impracticable to maintain the price of diamonds when there were too many producers in the market.

At present, the entire product is taken over, at a more or less fixed price per carat, by a very wealthy syndicate in London, which disposes of it to the various diamond merchants, and to-day the Kimberley diamonds supply the chief markets of the world. The following details, taken from the annual

report of the De Beers Consolidated Mines, Limited, for the year ending June 30, 1897, which was a fairly representative year, are of interest:—

Number of loads (16 cwt.) of blue ground hoisted		2,515,889
Number of loads (16 cwt.) of blue ground washed		3,011,288
Number carats of diamonds recovered		2,769,422¾
Amount realised by sale of diamonds	£3,722,099	3s. 3d.
No. of carats per load of blue		0.92
Amount realised per carat sold.	($6.45)	26s. 10 6d
Amount realised per load	($5.93)	24s. 8.6d
Cost of production per load	($1.77)	7s. 4.3d
Profit per load	($4.16)	17s. 4.3d

The diamonds produced realised as above and the total expenditure amounted to £1,689,538, including the amount written off for depreciation on machinery and plant of £175,524, and interest on company's bonds, £183,415, leaving a profit of £2,032,561, of which there was paid out in dividends, £579,582, or 40 per cent. on the capital stock of £3,950,000.

Heavy obligations were, of course, incurred at the time of the consolidation of the divers large interests in Kimberley diamond mining, of which debentures are still outstanding to the amount of £3,572,100, bearing interest at 4½ per cent. and 5 per cent. Of this there were paid off last year £123,840, besides the percentage of profits to the three Life Governors, Messrs. Alfred Beit, Cecil J. Rhodes, and F. S. P. Philipson-Stow, of £120,365. These figures speak for themselves, and give evidence of the permanent basis upon which this industry has been established.

But a description of the latter is incomplete without the mention of the Kafir workmen, of which there are about 7500 employed underground and on the surface. They are of various East Coast and North Country tribes, Zulus, Basutos, Shangaans, Inhambaans, Bechuanas and Matabele, and when they apply for work they are obliged to sign for a certain period of time, not less than six months. Once inside the compound they are never allowed outside until their time of service is up, going to and from the mine through tunnels or covered ways. Stores in the compound supply them with anything they wish to buy; their quarters are kept whitewashed and clean, and the hospital is exceptional in its appointments and neatness.

They have a little chapel where the writer, visiting on Sunday, listened to a native preacher discoursing volubly in one Kafir tongue and followed as glibly by the native interpreter at his elbow, who translated into the dialect more familiar to his hearers. These chaps are well cared for, happy and contented, as proven by the fact that many have been there for years, and the secret of it lies in their not being able to get drink.

If we, in Johannesburg, could only be allowed to introduce this system of compounding the "boys," the major part of our labour difficulty would immediately disappear; but thus far the liquor interests have prevailed, and the Boer government at Pretoria turns a deaf ear to all petitions.

The Kimberley Compounds are covered with a wire netting to prevent the throwing out of diamonds, it being found that old tins and similar articles were utilised for this purpose, on the chance of picking them up outside the walls after dismissal.

A certain percentage of the value of the stone is given to the Kafir who finds it underground or elsewhere and delivers it to the mine officials. In the month of July of last year £472 were thus paid out, showing that this method of checking theft is not ineffectual. Convict labour is used in the sorting house, and is always under vigilant watch, and as every impediment is put in the way of the disposal of the diamonds by law, it would seem that loss by theft is on the decrease.

Of the other mines at Kimberley, the Kamfersdam has but just started, and is working out the yellow ground at the surface. The best yield with which this mine is credited is 10 carats per 100 loads, and of inferior quality, worth about 14s. per carat; but it is expected that better ground will soon be encountered. The Dutoitspan mine, owned chiefly by the De Beers Consolidated, has been closed down for a number of years past, as also has all the portion of the Bulfontein pipe owned by it.

The Standard and New Bulfontein companies are working on comparatively small blocks of claims on this latter deposit. The former company's yield is stated to be 20 to 25 carats per 100 loads, and that of the latter, 33 carats per 100 loads, but their output is inconsiderable.

The Wesselton mine, lying about four miles southeast of Kimberley and close to the border of the Orange Free State, was discovered in 1890, and, six years later, came into full possession of the De Beers Company. The mine is a very large one, containing 1125 claims, and an interesting feature is the fact that this ground was covered with a tufaceous limestone in which diamonds were found, showing it to be later than the "pipe" rock, or Kimberlite, and formed from the evaporation of water containing lime.

The original owner took out about 5,000,000 loads, mining the yellow ground to a depth of 70 feet. The De Beers Company are now taking out a second cut, about 60 feet in depth, but still containing considerable yellow ground. This Wesselton mine is now working full swing. In one month (25 days of 10 hours each) they mined or quarried a block of ground 600 feet long, 65 feet high, and 45 feet wide. The mechanical haulage to convey this ground to the washing plant passes through a cut in the side of the crater-like excavation, and as it has now the maximum grade for rope and jockey of 1 in 5, underground mining will probably be resorted to after this layer is taken off.

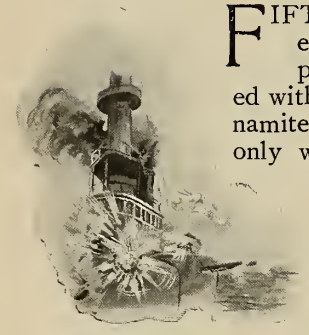
The yield of this ground is comparatively low, being but 16 to 20 carats per 100 loads; but the quality of the stones is much superior, averaging $10 (£2) per carat, as against $6.45 (£1., 5s., 10d.) for the De Beers and Kimberley diamonds (in 1897), and, in addition, the mining and washing can be done for about half the cost of those mines. For instance, a pan will treat from 600 to 700 loads of Wesselton yellow ground, as against 300 loads of De Beers blue. Hence this mine will probably add very largely to the De Beers profits in the near future.

Outside of Kimberley the most prominent diamond mine is the Jagersfontein, which lies in the Orange Free State, about 80 miles from Kimberley. The yield is about 12 carats per 100 loads, but the value per carat is as great, or greater, than that of the Wesselton mine on account of the purity of the stones. In consequence, this mine is a paying concern, and it has the distinction of having furnished the largest and most valuable stone in South Africa, and probably in the world. It was a flat, almost rectangular, diamond, about two inches long, and from ⅞-inch to 1½ inches thick, weighing in the rough 969½ carats. The colour was blue-white, the quality exceptionally fine, and the value impossible to estimate. And yet this peerless stone need only be placed between the poles of a battery to burn completely to carbonic acid gas, leaving not a trace of ash behind.

Up to the end of 1897 the total weight of diamonds exported from South Africa exceeded 63,000,000 carats, or about 12¾ tons, of a value of approximately eighty-seven million pounds sterling.

TORPEDO GUNS AFLOAT AND ASHORE.

By Captain E. L. Zalinski, U. S. Army, Retired.



FIFTEEN years have elapsed since the experiments were started with the so-called "dynamite gun." But it is only within a few weeks, during the war between the United States and Spain, that any demonstrations have been made with the gun in actual warfare. This demonstration has been limited in extent. It has not as yet included a trial in the direction from which the best results are sure to be attained.

The absence of the United States dynamite cruiser *Vesuvius* at Guantanamo, Cuba, when Admiral Cervera's fleet made its exit from Santiago, prevented a practical demonstration as to the effectiveness of that vessel and her pneumatic guns against ships.

The guns and shells have been so frequently described that no attempt will be made to do so in this paper. The so-called "guns" are, properly speaking, torpedo-throwing machines, and should be considered only from this point of view. Comparisons, if any are made, should be drawn with the automobile and dirigible torpedoes, and not with cannon and their armour-piercing projectiles.

Before discussing the questions of the fields of usefulness of the pneumatic torpedo and other torpedo shell-guns, some review of the conditions involved in firing high explosives is desirable. There seems to be a lack of knowledge and haziness as to what should be accomplished in the minds of many who have been endeavouring to produce some forms of shell having a high-explosive bursting charge. An effort will be made, therefore, to present the matter as definitely as possible.

The object to be attained by torpedo shell charged with high explosives is—

1st, Torpedo attack of the underwater hull of ship;

2d, Structure destroying;

3d, Man killing or disabling.

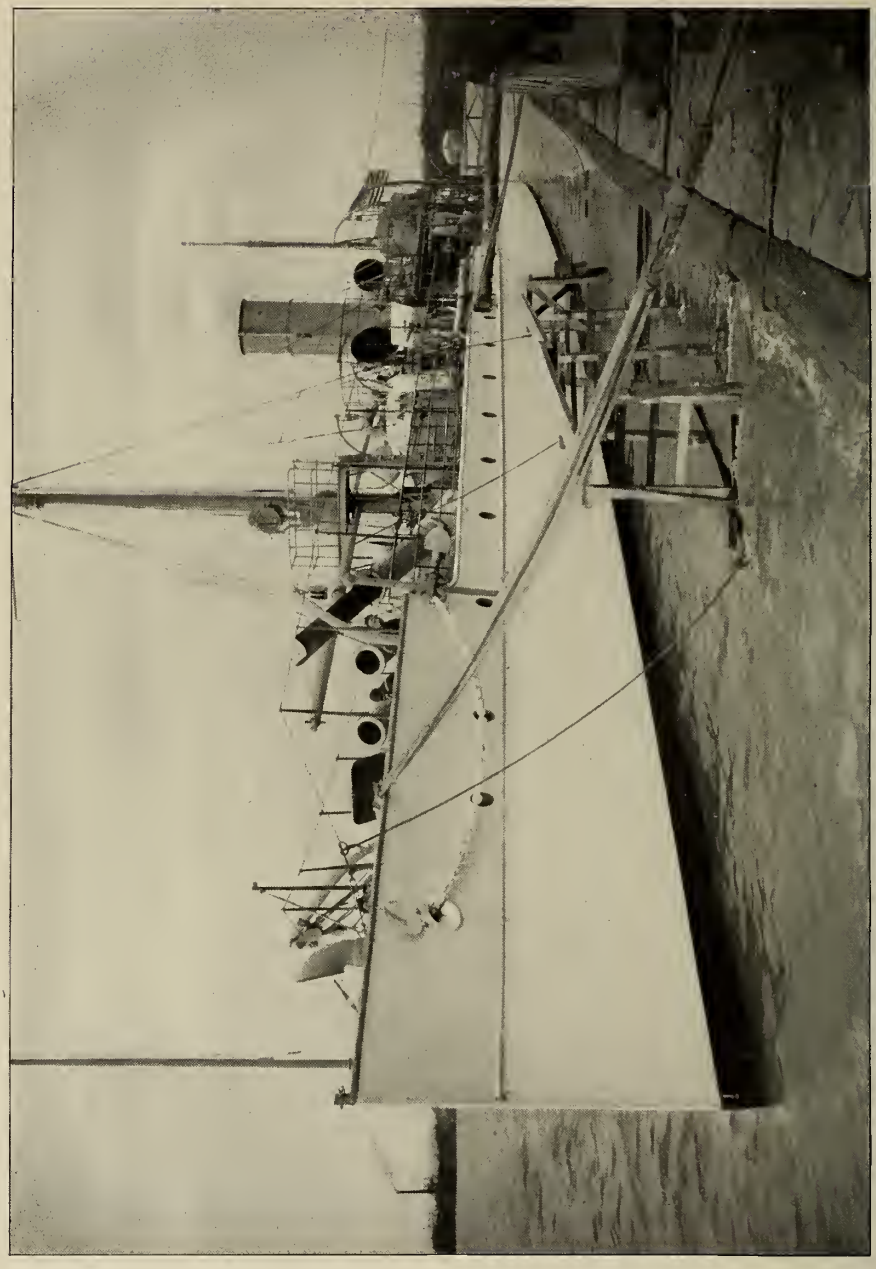
Experiments have demonstrated that considerable charges of dynamite or other high explosives may be exploded in contact with heavy armour without resulting in serious damage. This appears to be the case, especially when the charge is exploded in the ordinary way, by impact alone, or when the charge is in contact with the target, but not in any way tamped.

Experiments have shown also that where the initial point of explosion of the charge is at the point of impact with the target, the ensuing damage is considerably less than when the initial explosion takes place at the *rear* end of the charge, before explosion can occur at the point by impact. The high explosives are capable of a number of orders of explosion, of varying degrees of intensity of action. An initial explosion of fulminate of mercury, coupled with a larger charge of dry guncotton, or its equivalent, appears to be necessary to secure a high order of explosion.

The more insensitive the explosive to shock, and, therefore, the safer to handle, the more difficult it is to secure the maximum effect, on exploding it. This is especially true where there is a large mass of the explosive and it is in compacted form in the shell.

The possibility of securing only a partial or a low order of explosion is frequently overlooked. The mere fact of being able to throw a large mass of high explosive is of no avail, if the full potentiality of the charge is not secured

THE UNITED STATES DYNAMITE CRUISER 'VESUVIUS' BOMBARDING THE SANTIAGO HARBOUR FORTIFICATIONS.



THE UNITED STATES DYNAMITE CRUISER "VESUVIUS," CARRYING THREE 15-INCH DYNAMITE GUNS.

by a suitable detonation of that charge. When it is suggested that a large charge of this or that insensitive high explosive has been safely thrown, we find that the complete detonation of such a charge is assumed with insufficient basis of proof of the actual accomplishment.

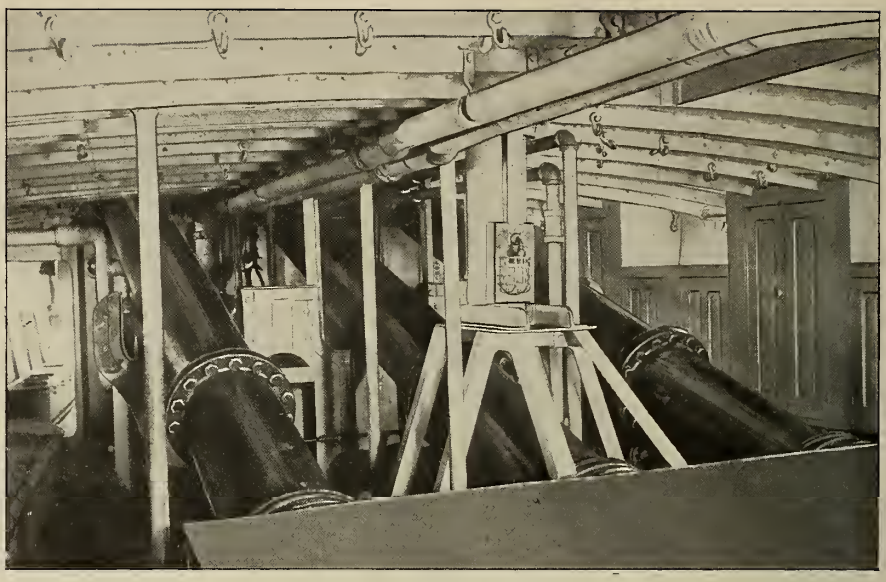
If the shell contains large charges of the explosive, the walls of the shell must be necessarily thin, and perforation of the armour is out of the question; the explosion is likely to take place outside of the armour, doing but little real damage.

If it is desirous to have the shell perforate the armour and explode after perforation, the walls of the shell must be very thick, and the capacity of the shell for the explosive is very much reduced. Such a shell could not be of use to secure torpedo action against the under-water hull of the ship. Where large masses of explosives are thrown in a torpedo shell, they are not likely to produce any very notable effects, other than moral, on striking the armoured over-water hull of a ship.

To produce effective torpedo action against the under-water hull of a ship, a considerable charge of high explosive must be thrown. To increase its danger radius and to provide for the greater subdivision of the under-water hull of the future, the charge must be made as large as possible. In making torpedo shells of large capacity, as has already been mentioned, the walls of the shells must necessarily be very thin.

In this last case unless the pressures in the gun are kept low throughout, there is danger resulting from the chances of the thin walls of the shell being crushed by the maximum pressure. In other words, the shell and its charge must be adapted to the desired objective of the attack, and cannot well serve both for successful attack of the under-water hull and armoured over-

THE DYNAMITE GUNS IN THE BOW OF THE "VESUVIUS."



A VIEW OF THE GUNS BETWEEN DECKS.

water hull. Both kinds may have a field of usefulness, and they must be especially provided for one or the other purpose.

The shock of the " set-back " on firing a shell charged with high explosives is greatest on the lowest layer of the explosive. This becomes greater in proportion to the weight of explosive. The ratio of weight of the charge to the total weight of the shell determines the proportion of the shock which must be safely sustained by the explosive. Where, then, the charge is very large, there is a twofold danger, resulting from a possible crushing of the necessarily thin walls of the shell and the greater ratio of shock sustained by the explosive. It follows,—1st. That a small amount of high explosive can be fired safely from powder gun with ordinary charges of powder because of ample thickness of walls of shell and small ratio of total shock borne by the explosive.

2d. Such shell may be made to perforate armour, carrying the explosive with it.

3d. Where torpedo shell, having large charges and thin walls are fired, the maximum pressures must be low enough not to crush the walls of the shell, and ordinary guns and ordinary methods will not serve.

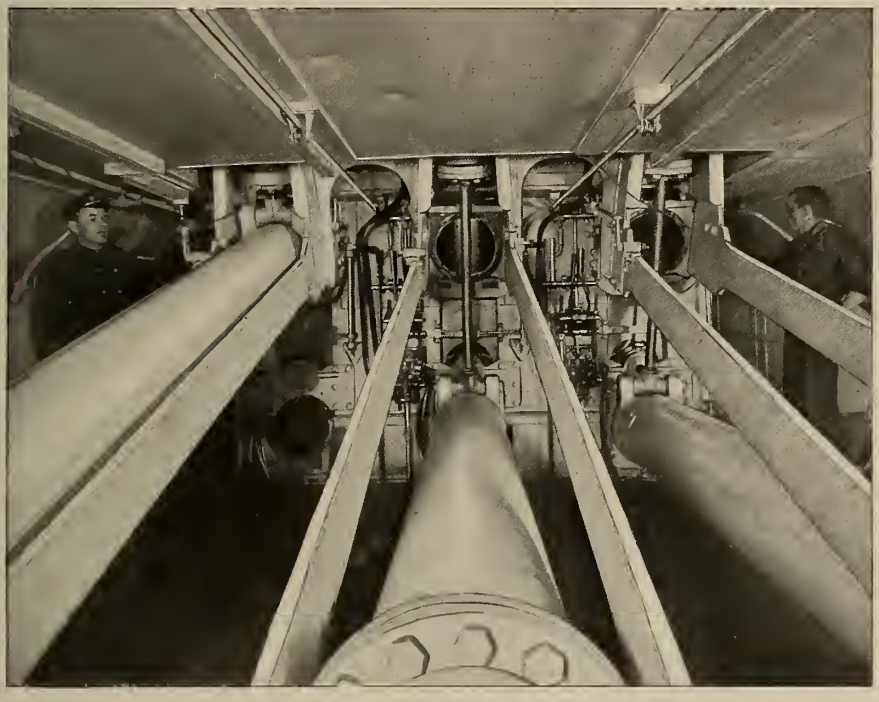
Consideration of the foregoing will indicate the reasons why the pneumatic gun system has thus far been the only one that has been successful in throwing very large charges of high explosives, and that without a single accident. All other methods, while successful as long as the charge of explosive was but a small percentage of the total weight of the shell, have ended disastrously when the proportion became greater than, say, 20 per cent. They have, at times, met with some success, but such success was not sustained to any extent that would justify adoption into actual service.

The development of the gun was pressed to the construction of as large a calibre as 15 inches, because it was early evident that its greatest utility would be as a torpedo-throwing machine, designed chiefly for the attack of the under-water hull of vessels. To be successful there, the large charges were requisite. The over-water hull, where heavily armoured, could not be perforated, and could not usually be much damaged by the action of a charge of high explosives. Considerable injury

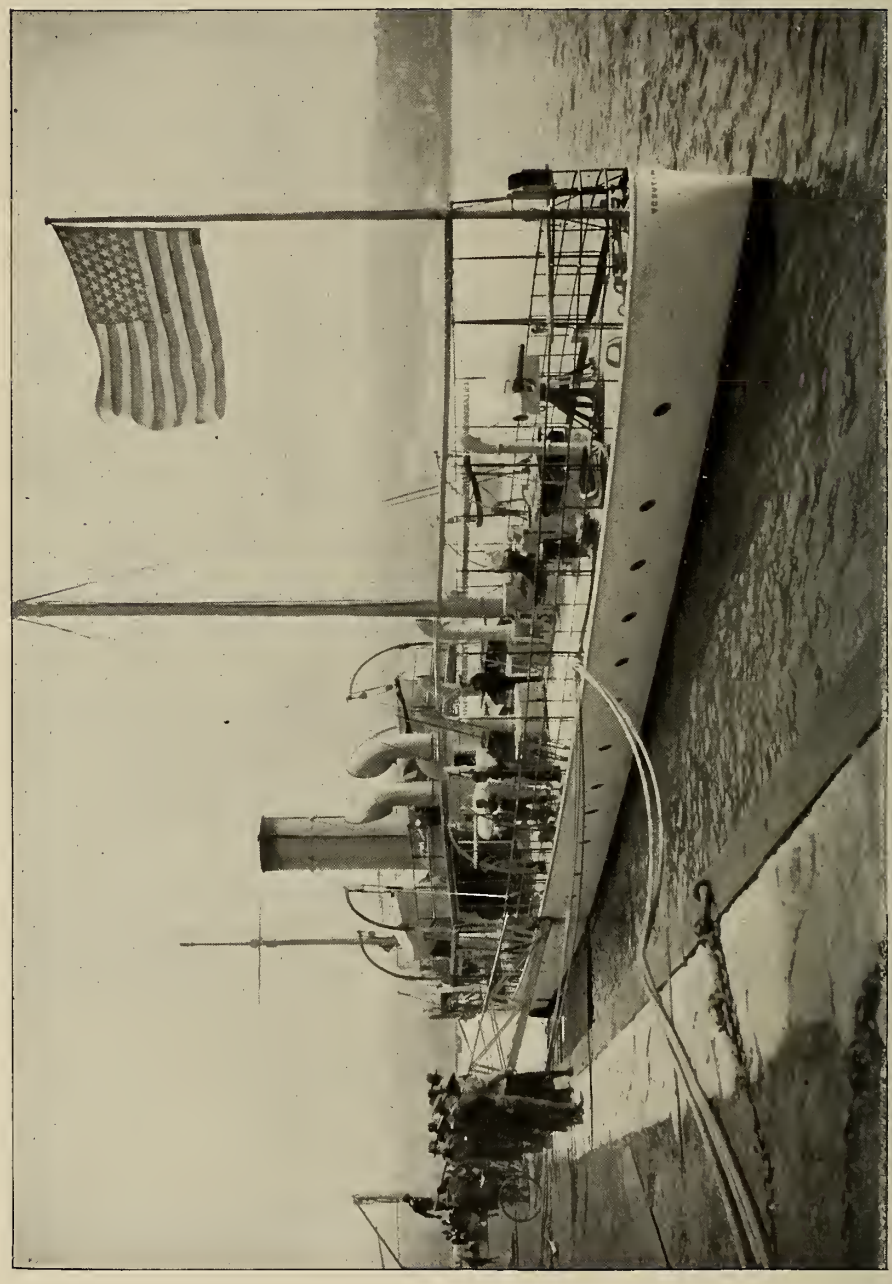
would ensue where such shell would strike the unarmoured or more lightly armoured parts. An ordinary projectile, however large in calibre, might perforate the over-water hull without necessarily putting the vessel out of action. But a perforation of the underwater hull by torpedo action is likely to prove fatal.

Torpedo guns, when used in land defences, should be looked upon as auxiliary and supplementing the fixed submarine mines defending a harbour. The mines may be removed by various methods of countermining, and, once removed, are difficult to replace, particularly in the presence of an enemy. Not alone may the submarine mines be removed by the action of the enemy, but in the course of an action they may be removed by the defence in endeavouring to blow up the enemy's fleet manœuvring in the harbour. The fire of torpedo guns can, in such cases, be directed on that portion of the torpedo field where the mines may have thus been removed.

When the firing is from a fixed platform, as is the case in shore defences, it has been shown to be extremely accurate. This follows from the uniformity of the air pressures and great care in making the projectiles. Where the ranges can be ascertained, as is likely to be the case in seacoast fortifications, the great accuracy of firing which has been shown to be possessed by the pneumatic torpedo guns should make an attack, coming within their range of fire, extremely hazardous. As an example of the accuracy of fire obtainable from shore, the writer would mention that of some trials at Shoeburyness. Three rounds were fired at about 2200 yards, of which two rounds entered the same hole in the sand, the other round being two or three yards from this. At 3500 yards five shots out of six were placed in a space no larger than a billiard table.



AT THE BREECH ENDS OF THE GUNS, ILLUSTRATING THE MANNER OF LOADING.

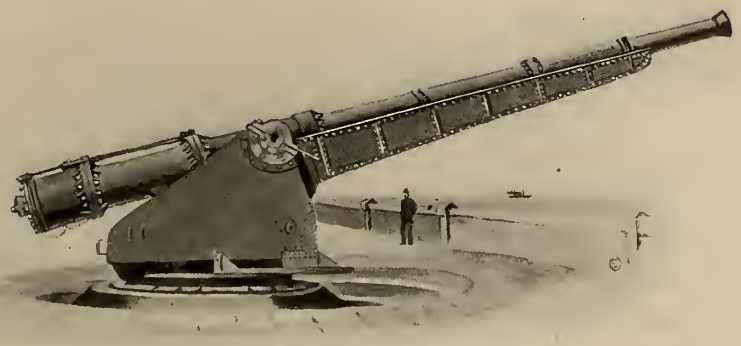


A STERN VIEW OF THE "VESUVIUS."

In an official test of three 15-inch guns in San Francisco harbour, 75 per cent. of the shots fell, at a range of 5000 yards, in a rectangle measuring 360 feet by 90 feet. The contract requirements were only 34 per cent. within such a rectangle. A rectangle of 210 feet by 153 feet would have contained all the rounds fired.

In the trial of the 15-inch gun before the United States Naval Board, of which Captain Casper Goodrich was president, the contract requirement of landing 50 per cent. of shell fired, in a rectangle 150 feet long by 50 feet wide, at a distance of 1 mile, was exceeded. The shots, either above or below the water-line, when 2097 yards distant.

"There is, however, another effect which ought not to be neglected, viz., the torpedo action of a suitably fused shell passing under the ship. As the lateral errors are insignificant throughout the various series, it is fair to assume that the chances of inflicting damage on a vessel, either way placed, are thereby materialy increased. Since the *Silliman* was destroyed in this manner such a supposition is logically admissible. Granting that it adds only one more chance to each phase, and we see that of the nine shots fired at 2100



A DYNAMITE GUN FOR COAST DEFENCE.

following extract from the report of the board is pertinent:—

"The method of graphic analysis employed to ascertain the effect produced by the groups of shell fired at the three principal ranges shows that a moderate-sized ship, broadside on, whose centre was anywhere between the limits of 1988 yards and 2218 yards, would have been struck by from one to five projectiles, either above or below the water-line. If end on, her centre being from 1946 yards to 2248 yards removed from the gun, she would have received from one to seven of the nine shots fired. Again, were the ship an average ironclad, 333 feet long, with corresponding draught of water, etc., she would have received all of the nine yards, eight would have been effective against a 300-foot ship, end on, and distant from 2015 yards to 2126 yards.

"At the 1700-yards range a similar ship, broadside on, would have been struck by from one to three projectiles, according as her centre passed over the space between 1625 yards and 1745 yards. On the other hand, if end on, she would have received an equal number when changing her distance between 1574 and 1786 yards; and the number of injuries received might be increased from one to two or from two to three, within the same limits, through torpedo action.

"At 300 yards range, a ship broadside on would have received from one to three shots between the limits of dis-

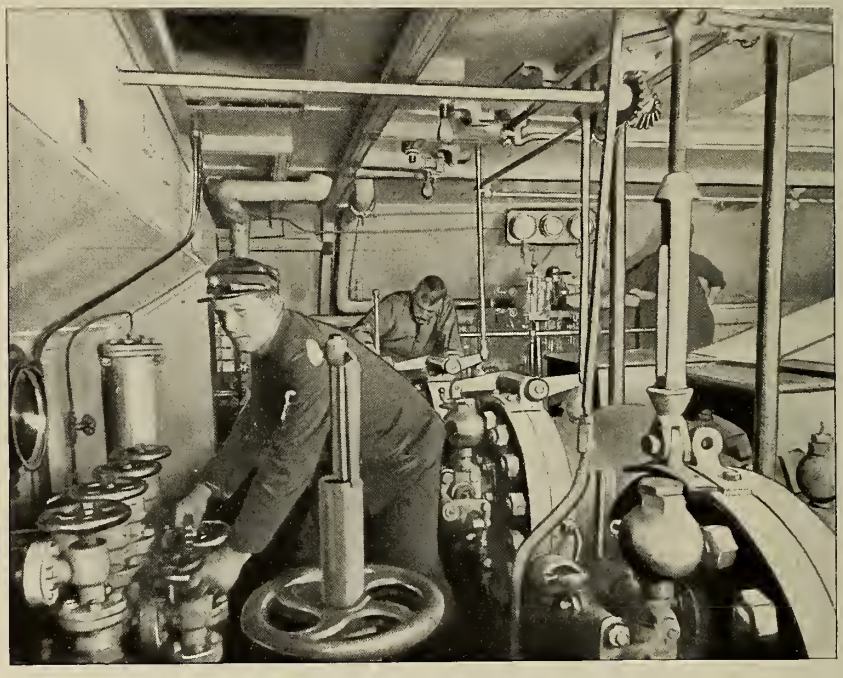
tance of 329 yards to 451 yards. End on, she would have received from one to two or from two to three shots between the limits of 298 yards and 482 yards.

"It appears, finally, then, that projectiles, either carrying, or capable of carrying, 200 pounds of high explosive, were thrown to distances varying from 1¼ miles to 90 yards, and that, at the ranges selected for grouping, viz., 2100 yards, 1700 yards, and 360 yards, not less than one-half of the projectiles fired fell in the same standard target with the trial shot."

The report of the board which tested the guns when on board the *Vesuvius* was equally good as to accuracy of fire obtainable.

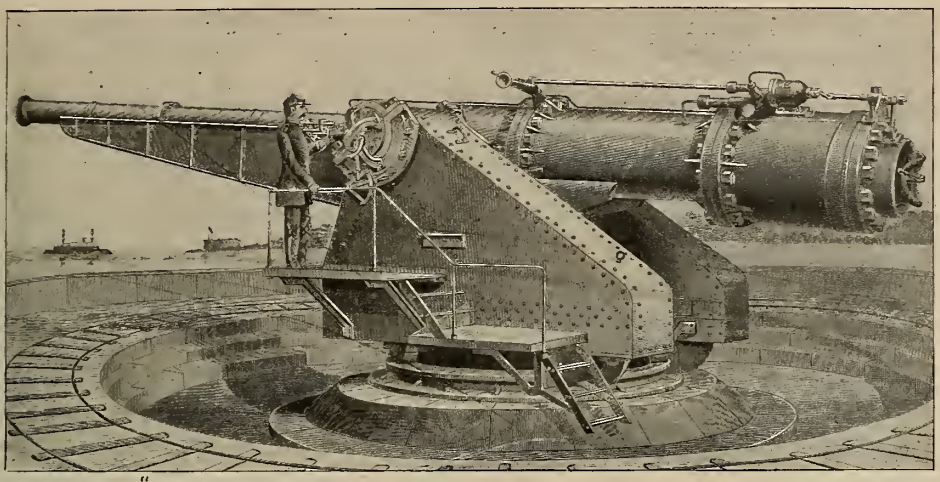
The chief defect which was then noted was the failure of the fuses to act. This, however, does not detract from the accuracy of fire obtainable, and has since been remedied. The trouble in this last case was due to the use of a new form of fuse without the necessary preliminary trial, which is always essential when modifications are made in any mechanism. While the general plan adopted may be correct, defects in minor details frequently cause failures. The well demonstrated accuracy bespeaks possibilities of securing effective results.

Recent experience in defending the harbours of the United States by means of fixed submarine mines has indicated the great inconvenience which the traffic of seaboard towns would find when



IN THE ENGINE ROOM OF THE "VESUVIUS."

measures are taken in placing the submarine torpedo defences for the harbour. Therefore, hereafter, in such cases, it might be well to place torpedo guns to cover such portions of the channel as are most needed for carrying on the traffic of the port, at a minimum of inconvenience. Of course, when an attack by a hostile fleet becomes imminent, these could be supplemented by placing more mines, which, however, would practically close the harbour for traffic. Meanwhile, before such action



BY COURTESY OF THE "SCIENTIFIC AMERICAN."

ONE OF THE 15-INCH DYNAMITE GUNS AS INSTALLED AT SANDY HOOK, NEW YORK, AND AT THE ENTRANCE TO SAN FRANCISCO HARBOUR. RANGE WITH 1000-LB. SHELL, 2400 YARDS; WITH 240-LB. SHELL, 6000 YARDS.

is taken, the torpedo guns in the shore defences will measurably protect against any sudden forays which the enemy might make.

With sufficient of these or similar torpedo guns mounted in the defences of any harbour, an enemy could not assail them with assured impunity. The shell of the torpedo guns would necessarily be as effective as the ordinary fixed mine is, having a similar charge, provided it is placed and exploded sufficiently near the enemy. That this may be done, has been demonstrated by actual experiences, some of which have been cited.

In considering the torpedo gun on shipboard, criticisms have usually been made because of the difficulty of firing from an unstable platform, but other guns afloat are subject, in a great measure, to the same objection. The high-angle fire of the torpedo gun is often cited as an objectionable feature, but it has some advantages which are not ordinarily conceded. Among these are the following:—

High-power guns, with their flat trajectories, have as their target only the vertical projections of the over-water hull of the ship. A very slight change of the angle of elevation of these guns produces very considerable change in the height at which the shot would strike the target. With the change of about one-fourth of a degree of elevation at one mile range, the shot would go under or over the point aimed at, a vertical distance of about 23 feet.

The pneumatic gun, however, with its high angle fire, has as its target the vertical projection of the over-water hull of the ship, the entire deck and a zone around the ship, of from 10 to 40 feet, according to the charge. A change of angle of elevation of one degree would make a change in the range of only about 60 yards. Thus with a slight variation due to changes in elevation, and the greater size of the available target presented, the chances of securing effective results are more than fair.

The high-angle fire from the guns as mounted in the *Vesuvius* also presents advantages for the attack of high sites in fortifications, as was practically demonstrated in the attacks at Santiago. This last use for the gun has never been advocated as likely to produce any great material results. These can only be looked for when the shell strikes within an inclosed space. In such case there is no question but that both the moral and material effects produced by the explosion are likely to be very great.

Considering the *Vesuvius* and her guns as compared to ordinary torpedo

boats, it would seem that the combination is a much more effective one for offensive action than that of the best class of torpedo-boat destroyers. This, unfortunately, has not been as fully demonstrated, practically, as could be wished, owing to the lack of opportunity. On the other hand, it has been shown that torpedo-boats have an infinitely smaller chance of coming near enough to the vessel they wish to attack so as to strike them with torpedoes. The *Vesuvius* could commence operations at 2000 yards with fair chances of success, instead of having to approach to within 300 yards, as is the case with the torpedo-boats.

It is most unfortunate that Admiral Cervera's fleet attempted to escape from Santiago at a time when the *Vesuvius* was probably coaling at Guantanamo. Had she been at hand she would have had some chance to get near enough to get in a shot or two. This is evidenced by the experience of the U. S. S. *Gloucester*, which, although no more protected than the *Vesuvius*, succeeded in getting within a mile of the enemy's ships without suffering any material injury.

The *Vesuvius* is not presented as an example of the best arrangement which could be secured by the pneumatic guns or any other torpedo guns in a vessel built for the purpose. She was the first of her kind and was the first swift vessel which was built in the United States. Everything was made to conform to the requirements of speed and to enable the ship-builders to fulfil the contract as to this. Being the first of her kind, defects of design were to be expected. There was so much skepticism as to her usefulness that but little effort was made to secure the improvements which experience indicated to be desirable. Nevertheless, the vessel appears to have done such service as to secure for her and the guns a higher degree of favour than has been heretofore accorded them.

Torpedo guns, capable of throwing very large charges of high explosives could be placed in a fairly well armoured turtle-back ship, having high speed. The guns could be arranged so that they could be protected completely and kept altogether under the water-line until the moment of firing. Some of these torpedo guns could be arranged so that they could be trained should this be considered desirable. A vessel of this character, having a speed of, say, 25 knots, would be most formidable.

Tubes of large calibre could be placed in the bows of battle-ships and cruisers, having muzzles projecting just above the water-line, the body of the gun being entirely protected and under the water-line. Such tubes would be equivalent to giving the ship a ram of 1000 yards or more in length, and the chances of getting in this blow would be much greater than the possibility of securing a direct blow with a ram. Such guns, too, could be of large calibre and throw shells containing 1000 pounds of explosive to a distance of at least 1000 yards. For such work a gun would not have to be very long, and could easily be provided for. In the course of the writer's experiments he has held that pneumatic power was the only one available which assured fullest safety in throwing large charges of high explosives. Thus far, experiences in the United States and elsewhere seem to have warranted this assumption.

The writer now believes, however, that it will be possible in the near future to arrange powder charges in such a way as to secure moderate and uniform pressures. This will demand a special kind of powder and a special arrangement which will prevent the possibility of the pressures attaining a higher point than experiments have demonstrated to be well within the limits of safety.

Thus far, we have not discussed the use of small high-explosive shells for field operation, but their radius of effective action is necessarily small. To be thoroughly effective, moreover, such shells should be exploded in the midst of a body of troops, and to do this requires an accurate knowledge of the range.

Comparing this with the effect of shrapnel, fired by ordinary field artillery, we find that the shrapnel, on bursting, throws out a sheaf of missiles, each one

capable of disabling a man for a distance of between 200 and 300 yards in front of the point of bursting, and scattering in a cone having an angle of about 15 degrees. This would give a dispersion of about 50 yards at a distance of 200 yards. Considering that the open order is the usual formation which troops take under fire, the chances of the shrapnel securing results are much greater than those of the torpedo shell. It is not desirable to use a ton to kill a man where a few grains will serve. The torpedo shell, if exploded in the midst of a group of men, will, undoubtedly, tear them to pieces and mangle them; but it is not desirable in war to more than kill men, and it is better to wound them rather than to kill them.

There can be but little question that torpedo guns, throwing shell containing very large charges, will play an important part in the warfare of the future. Their rôle will be both offensive and defensive. For naval operations, they will largely replace the unsubstantial and expensive myth of the short-ranged automobile torpedoes. The first nation to recognise this and act accordingly in its naval armament will surely reap an enormous advantage in so doing. Whilst the present war between the United States and Spain has not afforded a practical proof of the power of the torpedo gun, as against war vessels, it has at least demonstrated that the value and importance of the automobile torpedo has been overrated.

Thus far the penumatic torpedo gun has alone successfully thrown large quantities of high explosives. A mere statement that some great thing may be done is not a sufficient basis for assuming it as an accomplished fact and proceeding to act thereon. A logical de duction from what has been actually done, gives a reasonable basis for a conclusion as to what is likely to be practicable.

But the practical execution of the idea, when it is a matter of throwing large masses of high explosives, must be carefully carried on, step by step, cautiously and surely. There is no room for errors or "I thought so's."

The writer's arguments and conclusions are intended to refer to torpedo guns in general, whether compressed air, gases in any form, or gunpowder are used for propulsion.

GENERAL DISTRIBUTION FROM ELECTRIC CENTRAL STATIONS BY ALTERNATING CURRENTS.

By Herbert A. Wagner.

WITH all that has been done in recent years with alternating currents for power distribution, their use from central stations for lighting purposes has been comparatively restricted; in fact, few such alternating central stations in the United States, so it has been claimed, have been successful if judged by the standards of the magnificent Edison properties in many of the larger cities. The fault has been, not with the alternating current itself, but with the method of its application. Of this an instructive review has been given by Mr. Wagner in a paper read recently before the National Electric Light Association, from which the following extracts have been made.— THE EDITOR.

The early alternating-current stations were installed on the principle that the drop in lines with distribution at 1000 volts was practically negligible. Two wires were run out from the station, passing along those streets where light was to be furnished, and lights were connected at any desired points between the station and the farthest end, without reference to such trifling considerations as difference in potential. Distribution was attempted in this way for years, and in many places is still in operation. Lines are even being constructed to-day without any notion of a system of feeders and mains, although an almost perfect system for the maintenance of uniform pressure was in operation in many Edison stations before the first alternating station was in existence. Fortunately for the operators of such models of simplicity, the current delivered has usually been so small in quantity that with the proverbial No. 6 wire, which seemed to possess virtues not affected by distances, the difference of pressure between neighbouring customers rarely exceeded 10 per cent.

The regulation was all effected by means of the dynamo field rheostat, and the pressure indicated by a voltmeter on the secondary of a transformer whose primary was connected to the bus bars on the switchboard. A few lamps were also often operated by the same transformer to light the switchboard or other parts of the station. The station attendant was, of course, in absolute ignorance of the pressure at any point on the lines where lamps were used. The pressure was, therefore, usually run high enough to be on the safe side.

Later a compensating voltmeter was produced that could be adjusted for any drop in the lines. It was ingeniously arranged so that a small series transformer in the main line would send currents opposing those operating the voltmeter, thereby making the needle or index drop back approximately proportionally to the current in the line. This device was a great help, and caused the drop in lines to jump into prominence at once. It would be quite perfect if the drop in alternating-current lines were proportional to the current, but it is not. The power factor of ordinary alternating-current systems is usually quite low at light loads, and, except

with very small wire, an ampere may therefore produce much more drop proportionately at light load than at heavy load.

The usual system of distribution provides a separate transformer for each customer. In many cases, this implies the use of a very small transformer. It is impossible to make the efficiency of small transformers high. As each customer may at times use all of his lamps, he must have full transformer capacity for such an emergency. The ordinary ratio between maximum station loads and the number of lamps connected is in most cases under 50 per cent. where meters are employed. The transformers then, being of a total capacity equal to the number of lamps connected, average at best only 50 per cent. of their rated capacity at the maximum station load. In most stations the average load generated is much less than 25 per cent. of the maximum load, and, therefore, with twice the transformer capacity of that represented by maximum station load, the average transformer load would not exceed 10 per cent. of the transformer capacity, all the year round.

The efficiency of the average modern transformer of usual size at 10 per cent. of its rated load is not over 65 per cent., and the average of transformers at present in use not more than 50 per cent. It is perfectly safe to say that there is not an alternating-current station to-day using individual transformers for each or neighbouring customers that can show an average efficiency of distribution of over 60 per cent., and few that can show over 50 per cent.

In Europe it is, to some extent, the practice to use transformer sub-stations with low-potential distribution from these points. Transformers are cut in and out at these sub-stations by attendants according to the demand for current. It is doubtful if, after paying interest on the investment in property and housing for these transformer stations, together with the investment in instruments and switches required, and the attendants' wages, there is very much saving effected. Had we nothing better to turn to than these systems, the cost of distribution from large stations would be extreme compared with the direct-current, three-wire system, and competition with the latter could not be a success.

Another important consideration is the efficiency of lamps used. To employ successfully the highest economy lamps a very uniform pressure must be maintained. With the usual alternating-current system, and with an equally good disposition of feeders and mains, the variations of pressure will exceed those in a direct-current system by nearly 3 per cent., on account of the transformer drop, and to secure even this limit of variation pressure wires must be used with each feeder. It is not surprising to find, therefore, that almost all alternating-current stations are using lamps requiring 20 per cent. more current than those used by direct-current stations.

I cannot refrain from remarking here that to operate any station, alternating or direct current, without pressure wires, is to be worse than penny-wise and pound-foolish. In any alternating-current station employing overhead wires, the saving in lamp renewals would equal the cost of pressure wires in little over a month's time. I might also add that the total loss of lamps is not the most serious result of variations in pressure. Such variations cause a rapid decline in candle power, and low candle power means disaffection of customers and the increased use of gas.

On the plans of the system of distribution of a low-tension direct-current system a remarkable network of feeders and mains is laid out, most carefully calculated for the maintenance of uniform pressure. Means are provided for regulating more or less independently the pressure on each feeder. From numerous points in the system, corresponding to the feeder terminals, pressure wires are brought to the station, and indicators show the pressure at all these points.

The necessity for using an enormous amount of copper and for locating stations near the centres of distribution are the only weak points of this beautifully

developed system, and the alternating current advocate had best endeavour to overcome those particular points and adopt the rest, instead of starting out anew and alone to develop another system from beginning to end. It is not too late, however, to begin afresh. At the present time the Edison three-wire system of distribution is the most efficient in use and the most nearly perfect in details. The usual system employed with alternating current is not efficient and does not admit of as close regulation, but it is vastly cheaper to install.

Comparing the cost of individual transformers and high-potential distributing mains with the three-wire system of mains at low potential, there is not a great difference in first cost in favour of the alternating. The direct-current feeders do, however, for the same distance cost about thirty-one times as much as those for alternating current at 1100 volts, 125 times as much at 2200 volts, or 500 times as much at 4400 volts. It would then appear that if we could apply alternating current to the feeders at high potential and transform down for the mains, we might reach the lower first cost of the ordinary alternating-current system and possibly retain all the best features of the direct current. To accomplish the former the transformers must be provided at a small proportion of the cost of the alternating-current feeder, and to do the latter they must not increase the average losses in the system. It is obvious that we could, with alternating current, move our station to any reasonable distance from our centre of distribution, and at comparatively small additional cost for feeders. The whole problem then seems to come down to transformer efficiency and means of regulation.

To consider the matter of regulation first. We see at a glance that we cannot use the direct-current method of regulation by supplementary bus bars, but we can use the booster method, and can, moreover, apply a static booster to each feeder to regulate within any desired limits and with as small gradations as necessary. In fact, the booster method of regulation was first applied to alternating-current distribution, and operates with much less average consumption of energy than either the supplementary bus or direct-current booster method. In this important consideration we can, therefore, improve on and simplify direct-current methods.

The means of regulation having been in this way provided for the feeders, it remains to be considered what we shall do to eliminate the effects of transformer drop. As we have determined on a secondary low-potential, three-wire distributing system of mains, we can altogether dispense with high-potential mains and limit the high potential to the feeders. If we do this, we can conveniently have the transformers of the same unit capacity as the feeders, and arrange each with its primary connected to its independent feeder and its secondary feeding into the three-wire mains. We know that the effects of our feeder drop are eliminated if we regulate by pressure wires from the feeder ends. In the same way the effect of our transformer drop may be eliminated by bringing pressure wires from the secondary terminals. The feeder drop and transformer drop, therefore, become one, and are cared for in the same way. We can even secure better general regulation than with the direct-current system, as we have a better form of feeder regulator and have eliminated the effects of transformer drop.

Now, to return to the transformer itself and its efficiency. It is evident that, with this system, the transformer capacity need be no greater than that required for maximum station load, instead of more than twice that amount or nearly equal to that required for the total number of lamps connected. This at once doubles the average load on the transformers, and raises the average efficiency. It also incidentally reduces the first cost of transformers in still greater proportion. We also know, however, that transformer efficiency at light loads is dependent on the iron loss, and that this is interdependent with the regulation or drop. If we can increase the drop, we can decrease the iron loss, and thereby greatly increase

the average efficiency. Having provided against any interference with the regulation of the system by the transformer drop, we can afford to increase that to the heating limit of the copper. In this way, a 100-K W transformer can be built with an average efficiency of over 98 per cent. The entire transformer loss can, moreover, be more than made up by the reduced loss in feeders, which we would naturally have with alternating current.

It has been my good fortune to have an opportunity to install a system of this kind on a large scale, which is now in very satisfactory operation. It is laid out exactly as a three-wire Edison system would be, except that there are no sub-feeders. A network of mains is planned as if for use with direct current. The feeders are all designed for 110-K W maximum load at 1100 volts, and at each feeder end is placed a 110-K W transformer feeding into the three-wire network in the same manner and at the same points as with the direct current system. The transformers are located in manholes of suitable design. From the secondary terminals of each transformer pressure wires are run back to the station. Each feeder has an independent regulator by which the pressure can be raised or lowered. There are no primary mains, nor any connection whatever between the primary feeders The regulators perform two functions. They are used to maintain the proper pressure as indicated by the voltmeters and also to divide the load between transformers in any way desired as indicated by the feeder ammeters. It is possible to shift the entire load from one transformer and feeder to an adjacent transformer in this way without sensibly affecting the pressure on the system, and an equal division of load between transformers can be readily maintained at all times if desired. The distribution of load on any large system is constantly changing as new customers are connected, and in large Edison stations certain feeders often become so overloaded that it is found necessary for their safety to put resistance in series with them to force some of the current to other feeders. The possibility of overloading any individual feeder beyond its share is absolutely provided against in the system described.

Extensions of Direct-Current System by Alternating Current.

Several large three-wire, direct-current stations are beginning to employ alternating current to extend their lighting territory beyond that possible or profitable with low-tension current. This is a recognition of alternating current which would not have been considered for a moment a few years ago. They now propose to use alternating current to transmit their energy at high potential to a distant sub-station, where it will be transformed to a lower pressure and then again transformed by means of rotary transformers to direct current, which is, in turn, distributed over the three-wire Edison system as if generated in the ordinary way. This is a very beautiful and instructive application of alternating currents and ingeniously designed machinery. It gives the manufacturers a chance to sell additional machinery, swells the company's real estate investment and gives work to the unemployed to operate the sub-stations.

The loss in the conversion to alternating current and back is about 15 per cent. in addition to the loss in static transformers and lines. This distribution might be accomplished without the additional machinery, wire, real estate, labour, and loss in efficiency. It is hardly to be expected, however, that those who have grown up under the protection or influence of direct current would use alternating current any further than absolutely necessary until they have grown more accustomed to the new mode of travel.

A much higher efficiency of distribution and better regulation could be secured by using the alternating-current system as it is, without transformation to direct current, and everything could be controlled from the main station without employing labour or apparatus at sub-stations. Why do they not use

it so? They say that many things cannot be accomplished as well with alternating current. If that is a challenge, we will accept it and try conclusions with them. Let us then anticipate these various objections and see what they amount to.

Efficiency.

We have already seen how a properly designed system of distribution for alternating currents may be made to exceed the direct-current system in efficiency, taking the latter under its most favourable conditions. If we then add to the usual losses in the direct-current system the losses in double rotary transformation and in static transformers, the very great difference in favour of the alternating current is still more marked.

Regulation.

It has been shown how very simple and reliable regulators can be provided for each alternating-current feeder, which will secure the closest possible regulation over any range desired, and this can be effected at a loss of less than 1 per cent. Such close regulation can only be secured with direct current by the use of a number of generators connected to auxiliary bus bars, or by connecting the feeder ends to adjustable resistance connected between the busses of two or more generators. The first cannot be realised in a rotary-transformer station, and the last is quite wasteful of energy. Regulators placed on the alternating-current feeders of the rotary transformers control alike the pressure on each rotary, and all the direct-current feeders supplied by the same, in exactly the same way as field regulation does on a direct-current generator. Such regulation can be effectual only with a number of small rotaries not operated in multiple. The best regulation can, therefore, undoubtedly be secured with the alternating-current system.

Operation of Arc Lamps.

It seems now to be the universal opinion among Edison station men that the inclosed-arc, long-burning lamp is destined to replace all the old forms of arc lamp. We will, therefore, consider this type of lamp only. Fully as well-burning lamps of this type are now made for alternating current. They are also about as free from noise as the direct-current lamps. Many will say, however, that it is impossible to get as much light from the alternating current as from direct curent. That is true if we state that the same energy in the arc produces less light with alternating current than with direct current. It has been determined that the alternating-current arc produces about 70 per cent. of the light to be obtained from the same number of watts in the direct-current arc. The usual direct-current inclosed arc requires five amperes at 115 volts, or 575 watts. How much of this is used in the arc? Somewhat less than 80 volts, or under 400 watts, the balance of over 175 watts being wasted in resistance.

With alternating current, 70 per cent. of the amount of light would be obtained with this 400 watts, or about 570 watts would be required to produce the same light. The alternating-current arc is best operated at about 70 volts, but inductive resistance is used to bring the pressure down to this amount. This inductive resistance consumes about ten watts' actual energy, making in all 580 watts, against 575 for the direct current for the same amount of light. This difference of five watts, or less than 1 per cent., is insignificant.

Motors.

The greatest argument used against alternating current used to be that it would not run a motor. It has long ago proved that it can, and that without a commutator. This subject now brings us to multiphase systems. There are two of these systems in general use, the two phase and the three-phase. Other systems are but modifications of these and will be mentioned as such. Motors can be operated with equal facility and efficiency on either system and have many distinct advantages over direct-current motors.

For long-distance power transmission

the three-phase system shows an economy in copper; but for lighting, or for lighting and power combined, it is not at all well suited. I might say that where lighting is a distinct feature, and first-class service is to be rendered from a large station, the three-phase system cannot be used successfully. On even the best generators, the windings are so entirely interdependent that a change of load on one phase will affect the pressure on the other two; but a defect even worse is the impossibility of regulating the phases independently for drop in the feeders if the load happens to vary differently on any two. Any regulator placed in circuit with one phase will effect about the same change of pressure in the adjacent phase within the usual limits of regulation. Regulation is then a question of the best possible averages, and at best is but guesswork. With the feeder and transformer drops found economical in practice, it would be practically impossible to keep the pressure sufficiently constant for high-efficiency lamps. The complication of wiring is also very serious, especially if the Edison three-wire system is used for distribution, as six wires would then be required, forming six circuits that must be kept balanced.

The two-phase system is subject to the same objections unless the two phases are used separately for lighting, in which case we have the complication equivalent to twice the number of generators and feeders.

For good regulation and simplicity, the single-phase system cannot be equaled by any multiphase system.

We can meet the direct-current advocates on the power question, therefore, on at least an equal footing save only one application met in central-station practice, namely, the operation of high-speed elevators. The alternating-current motor, multiphase or single-phase, cannot be controlled for this work as readily as a compound series, direct-current motor. It has taken several years, however, to perfect the mechanism for the control of direct-current elevator motors. Give us the same time and we will do it with alternating current. This field for power has only of late been opened to direct-current stations, and it is yet a question for debate as to whether it is a paying one.

Storage Batteries.

Here we come to the direct current advocate's last and greatest stronghold. To this he retreats with great confidence of safety. We may ask first whether storage batteries have yet been proved to be a valuable adjunct to the central station, cost and maintenance considered. It is true they are being tried by several large stations, and we watch eagerly for the results. They equalise the station load to a greater or less degree, and cut down the generator capacity for the peak. Are they, however, cheaper than generators, engines and boilers of the same capacity? Are the losses in transformation less than the cost of a few more attendants? Is their maintenance less expensive than that of generating apparatus? These questions cannot as yet be answered in the affirmative. But if the battery man's most sanguine hopes be realised, what then? If rotary transformers are good enough for the direct-current man to use to change the direct current to alternating current, transmit a good proportion of his load to a distance and transform again to direct current, why should not the alternating-current man use them to charge his batteries and then to transform their output back to his pet form of current? Loss in transformation, do we hear some one say? Not any more than with our contemporaries' long-distance transmission system, and, in this instance, they are small and unimportant, we are told. There is at least one station in the United States where storage batteries are being used in this way, and I believe with success, as storage batteries go.

The great desideratum in central-station practice is to be able to employ one system for everything. All current for all classes of service should be supplied from but one type of generator, be this direct-current or alternating current. In this way only can the

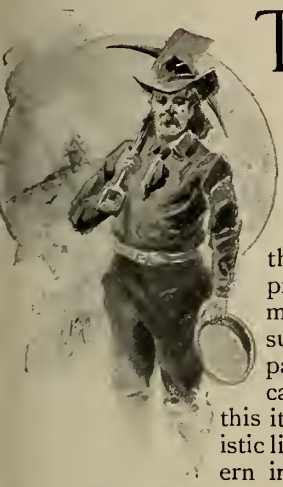
maximum output be accomplished from a given investment in machinery and apparatus and the greatest economy in operation secured. This has been accomplished in many stations where a limited range of service is to be provided. Arc lighting has, of all, been the most troublesome to provide for. How shall we operate our arc lamps from our incandescent lighting system, has been the anxious inquiry. The constant-potential arc lamp has answered this question for commercial lighting, but city street lighting cannot be so easily provided for. The Edison companies have done a limited amount of this from their three-wire system, but this can be done to advantage only in districts where mains have been provided for commercial lighting. For extended arc lighting, the small series machine with its belts and clutch pulleys still holds the fort.

I am able to state, however, that one large company has recently solved the problem to its entire satisfaction. This company furnishes 2600 city street lamps, lighting some 300 miles of street. These were operated by a small army of series arc machines. They were installed by a company that was acquired by purchase by the one first mentioned. As this company had long since adopted alternating current for its entire distribution, it was extremely desirable to be able to operate these city lamps from its large direct-connected alternators, thereby saving in fuel, attendance, floor space and reserve investment.

After a few months' trial of an experimental circuit with alternating current it was found perfectly feasible to operate the same direct-current lamps, slightly remodeled, on the same circuits of sixty or eighty lamps in series. A system of this kind was, therefore, adopted, and the company now has 2300 of these lamps in regular operation by alternating current in this way. The circuits are each provided at the station with a regular step-up transformer of a maximum capacity of 4000 volts and ten amperes, and the feeders to these transformers are treated on the switchboard in the same way as the feeders for incandescent lighting. It is quite usual for one generator to carry 2000 of these lamps. The lighting is satisfactory to the city, and the lamps give better service than when operated by direct current. There has been a very marked saving in fuel and attendance. The indicated horse-power per arc lamp is considerably less than with the direct-current arc lamps operated in the usual manner.

THE CYANIDE PROCESS OF TREATING GOLD ORES.

By Dr. Joseph W. Richards.



THE real story of the cyanide process is very recent history. Born into the practical world less than ten years ago, and a proved success only within six years, it has in this brief time taken a prominent place in the metallurgy of gold. Its success is due principally to careful chemical sponsorship, and in this it bears the characteristic lineaments of the modern invention,—great success due to scientific supervision.

For the benefit of the non-metallurgic reader, a brief sketch of its rise and present status will not be indispensable. The chemical principle involved is the solubility of gold and of most gold compounds in dilute solutions of potassium or sodium cyanide. For convenience, we will speak only of potassium cyanide, for which sodium cyanide is in all respects the exact equivalent. After the gold is obtained in solution, it is precipitated therefrom by any competent chemical reagent.

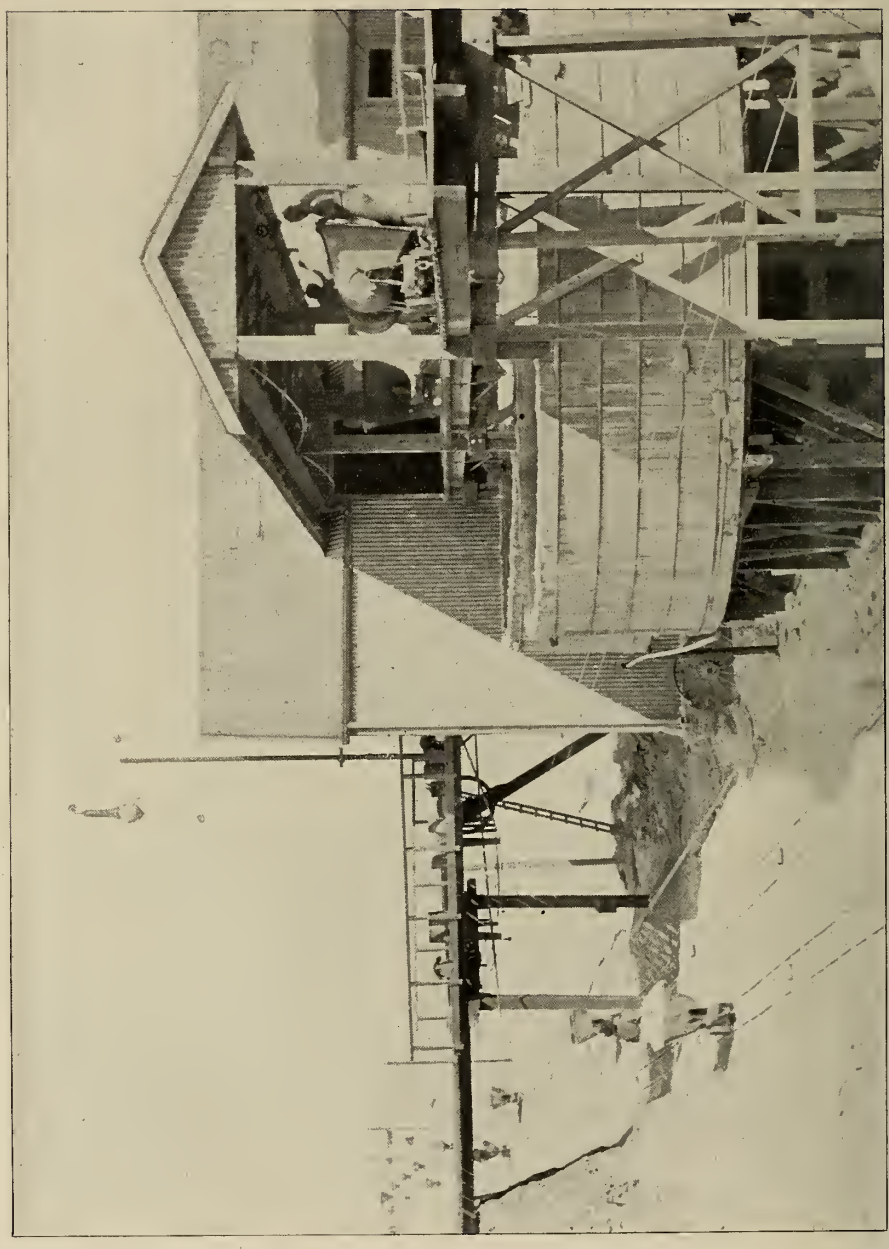
The process has been suggested by, and evolved from, the universally-applied process of gold plating, which consists, as is well known, in dissolving gold in potassium cyanide solution and using this as an electrolyte with pure gold anodes to replace the gold thrown down on the objects to be plated. This is Elkington's process, patented in 1840, and based upon the discovery of the great Swedish chemist, Scheele, that gold was soluble in solution of potassium cyanide.

The idea of using this principle to dissolve gold from its ores was a natural transition from the plating process, attempted in practice by several inventors in Great Britain and America, but never successfully until 1886. About that period J. S. MacArthur, of Pollokshields, and R. W. and W. Forrest, of Glasgow, made a systematic chemical investigation of the circumstances under which gold ores were thus attackable, the ingredients which interfered with the reaction, or destroyed the cyanide to no useful purpose, and the best methods of precipitating the gold from solution.

This investigation, conceived in a scientific spirit and carried out skilfully, was the basis of the present success of the process. However we may disagree with the later pretensions of these inventors, in which they sought to monopolise the credit for every practical idea there is in the process, yet they certainly deserve the credit for initiating its practical development. Their patents claimed more than was in justice theirs, and have been annulled in the Transvaal, where they have also attained their largest application.

At the present time there are in the neighbourhood of forty cyanide plants in the Transvaal, twenty-five in the United States, several in Australia and New Zealand, and scattering ones in almost every country on the globe, the value of the gold annually extracted by them being not far short of $15,000,000 (£3,000,000). The Transvaal plants no longer pay royalty for the use of the process; in the United States, some do and some do not; in other countries, generally, royalty is still paid. Either part of these users are in the wrong or part of them are being imposed upon.

Looking closer into the principles of the process, we will first consider the



THE CITY AND SUBURBAN CYANIDE WORKS, AT JOHANNESBURG, SOUTH AFRICA.

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question of dissolving the gold. The solution is known to take place slowly, and therefore a necessary condition is that the gold shall be finely disseminated through the ore, the finer the better; in fact, small lumps or nuggets are practically unattacked. Such "nuggetty" ore is best treated by other processes. It is not, however, necessary that the gold should be "native" gold; gold sulphide and most other gold compounds are also attacked and dissolved, with the exception of the class of ores known as "tellurides," in which tellurium and selenium occur, combined with gold and silver. The latter compounds are attacked slowly, and under some conditions not at all; a preliminary gentle roasting is in all such cases advisable. It is necessary that the ore be either finely divided, to enable the solution to get at the gold, or else that it be of a porous, spongy texture.

An economical question of great importance is the presence or absence of foreign substances which act upon the potassium cyanide and waste it. Among these are all acid sulphates of iron (from decomposition of pyrites), or of alumina (from alum shales), or any kind of copper mineral, except possibly native copper or copper silicate. The soluble sulphates can mostly be removed by simply washing them out with pure water before using the cyanide solution; the slightly soluble basic sulphates can be neutralised by caustic soda or lime water; but the copper minerals are generally regarded as incorrigible, and as unfitting the ore for the process.

Given, then, an ore which is free from copper minerals, or soluble sulphates, which contains the gold in an attackable condition and which leaches easily, the next question is the *modus operandi* of the solution. And here it must be kept in mind that the dissolving of gold in solution of potassium cyanide is not a very simple chemical reaction. Potassium cyanide plus gold equals gold cyanide plus potassium, is as impossible, chemically, as that twice two is six.

If, however, oxygen is present along with the gold, then the reaction does take place, because the oxygen combines with great energy with the potassium and throws the balance of power in favour of the decomposition. We then have—potassium cyanide plus gold plus oxygen equals gold cyanide plus potassium oxide, and the solution is accomplished, aided further, no doubt, by the energy with which gold cyanide unites with the excess of potassium cyanide to form potassium auro-cyanide.

A simple experiment will prove the necessity of oxygen for this reaction:—A strong solution of potassium cyanide in distilled water was made, put into a beaker, and a gold leaf totally immersed in it. After standing uncovered thirty-six hours, nothing had apparently been dissolved; on bubbling air gently through it for five minutes it all dissolved up clear.

TANK ROOM IN THE MERCUR MILL, UTAH, U. S. A.

The question has often been discussed:—"Should the ore be agitated to promote solution?" The consensus of opinion has crystallised into the following form:—If the ore is poor in gold, the solution itself, if properly aereated, will carry dissolved all the oxygen necessary for the solution of the gold, rendering agitation unnecessary. For richer ores, which will bear the expense of the mechanical power necessary to agitate them, such treatment is in most cases advisable, but in only few cases is it absolutely necessary.

In the days of the inception of the

LEACHING ROOM OF THE BLACK HILLS GOLD AND SILVER EXTRACTION CO., DEADWOOD, S. D., U. S. A.

cyanide process it was wittily observed that "it was no trouble to get gold out of the ore, but the difficulty was to get it out of the solution." This epitomises the chief difficulty of the process. The first to propose using cyanide solution on ores, specified in the usual *blasé* manner of the professional inventor, that "the solution may be evaporated to dryness and the residue fused in a crucible to metallic gold."

This sounds like the acme of simplicity; but, unfortunately, with the dilute solutions, which are alone feasible in practice, the cost of evaporation would be greater than the value of the gold contained in them. Again, another inventor specifies:—"The gold is precipitated by strips of metallic zinc," while experience shows that strips of zinc alone will not precipitate a particle of the precious metal. The ordinary gold worker is confounded, and even the chemist is nonplussed, by the obstinacy with which gold refuses to precipitate from these solutions.

From all ordinary gold salts the very weakest of reducing agents throw out the gold immediately. Those in common use are charcoal, hydrogen sulphide, copperas, oxalic acid. None of these, however, have the slightest effect on cyanide solution. Why is this so? Chemical research has disclosed the reason in the fact that the compound of potassium cyanide and gold cyanide is not a mere mechanical mixture of the two cyanides, but is an entirely distinct triple compound of potassium, gold and cyanogen, whose stability is somewhere about the average of that of the component cyanides.

It is, therefore, no longer a question of breaking up a simple gold salt; it is more a question of breaking up a potassium salt. Not only thermo-chemical data, but also electro-chemical observations, point to the existence of potassium auro-cyanide, quite analagous to the well-known salt potassium ferrocyanide, in which the potassium is the basic element and gold and cyanogen form the acid radical. Such being the probable truth in the matter, we must, in order to get the gold, literally dispossess the potassium, providing it with

some other negative radical, and then split up the gold cyanide.

Some of the strongest reducing agents can effect this. Charcoal, if used in quantity and given time enough, can do it. Sodium or potassium (used as amalgams), magnesium, aluminium and zinc can effect it, the latter only when in shreds so as to offer a large clean surface and with many jagged points from which gas can be liberated. The use of zinc turnings was patented by MacArthur and Forrest, but they afterwards abandoned their claim to it as a valid invention in the legal contest to exact royalties in the Transvaal. However, the use of zinc in this form was introduced by them, and remains the only chemical participant in actual use.

The chemical reaction involved is not simple, and brings into play the caustic potash which was generated during the solution of the ore. The zinc plays a double rôle. One-half of it splits up the auro-cyanide and precipitates the gold; the other half displaces hydrogen in the caustic potash. The bearing of these on the course of the precipitation is twofold.

First, if the zinc has a flat, smooth surface, the gas forms a thin layer on it which stops the precipitation; a jagged, uneven surface allows the gas to form into bubbles and so escape.

Second, the two zinc salts produced react on each other and produce insoluble zinc cyanide, which deposits on the zinc and hinders its reaction. This disposition can be prevented only by having a considerable excess of free potassium cyanide in the solution, to take up the precipitated zinc cyanide and form the soluble double cyanide, or, in other words, to prevent this precipitation. Experience has shown that when there is less than 0.1 to 0.2 per cent. of free potassium cyanide present, the precipitation of gold is very imper-

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THE WEMMER GOLD MINING COMPANY'S CYANIDE WORKS, JOHANNESBURG, SOUTH AFRICA.

CYANIDE TANKS OF THE CONGRESS GOLD COMPANY, AT CONGRESS, ARIZONA, U. S. A.

fect. Zinc can thus not be used with the more dilute solutions.

The question of precipitating the dilute solutions has been solved by Siemens & Halske's electrical method of precipitation. Briefly, the solution is electrolysed with cast iron anodes and sheet-lead cathodes. A recent improvement is to use lead shavings in bags, as affording more surface in a smaller space. The essential principle which must guide in electrolysing such very dilute solutions (0.01 to 0.05 per cent. of potassium cyanide, and 30 to 100 grains of gold per ton of solution) are to keep the electrolyte in gentle motion between the electrodes and to use a current of very feeble density (0.05 ampères per square foot).

Even with this weak current, the electrical efficiency of the precipitation is less than one per cent., but the loss of power is inconsiderable, as a five horse-power current precipitates $1,100 worth of gold per day. This method has been worked out very skilfully, and is now applied to about one-quarter of the cyanide plants in the Transvaal. It is not applicable to stronger solutions, because the unutilised 99 per cent. of electrical energy decomposes the cyanide present and causes great loss of that reagent.

We have now passed in review the principles used in the cyanide process as it is in general use. It is not the object of this paper to describe in detail the apparatus used or even the detailed method of working. For such data the interested reader is referred to any text-book on the subject of gold extraction of recent date (since 1893), the more recent the better. As conducted at present in South Africa, the material subjected to "cyaniding" is principally the tailings from amalgamation processes. These are already ground fine, and average $3 to $8 (12s. to 32s.) per ton. They contain nearly 40 per cent. of the total value of the ore, and, until the introduction of the cyanide process, were mostly thrown away, as they hardly paid for chlorination.

At present, they are divided into

three or four grades, of different sizes and states of oxidation, and each grade is treated by the cyanide process in some modified form, adapted to each grade. Chlorination has thus been displaced where it was formerly used by an intelligent application of the cyanide process. The zinc-gold precipitate is usually treated by oxidising the zinc at a red heat, and fluxing the residue down in a crucible. The lead-gold precipitate of the electrical method is melted down and cupelled.

In the United States there are no accumulations of old tailings to work, as in the Transvaal, and the process is being mostly applied directly to such ores as are suitable. The criteria of suitability have already been mentioned. An ideal ore for this treatment is the porous limestone of the Camp Floyd district, in Utah. This mining region consists of a bed of limestone, eight miles by ten, evidently once the bed of an ancient lake, varying from twenty to forty feet in thickness, and averaging six, eight and up to twenty dollars of gold per ton. Amalgamation does not extract much over one-fourth of the gold contents; chlorination is too expensive; and the cyanide process alone has treated this ore with success, so that the region is entirely an exposition of the application of the new process and has not inaptly been styled "the Johannesburg of America."

Every mill in operation in that district is a cyanide mill, and all are paying dividends; the only limit to the output is the capacity of the mills, as it is estimated that there are five billion tons of ore in the district, containing fifty billion dollars' worth of gold. Whatever its real value may prove to be, it is certain that at the present time the cyanide process in this one locality is increasing the gold output of the United States one and a half million dollars a year, and there is promise of almost indefinite expansion.

As carried on in the United States, the only important differences are that some ores, such as those of Camp Floyd, are treated in coarser sizes, rather stronger solutions are used (0.1 to 0.5 per cent. of cyanide), and zinc precipitation is used exclusively. It is also customary to treat the zinc-gold precipitate with sulphuric acid, to dissolve out the zinc, instead of burning it out, as in South Africa. The total cost of "cyaniding" ore varies from $3 per ton down to 70 cents, the latter figure being reached at one of the immense South African plants, which treats 1000 tons of ore daily.

A few words as to the directions in which the process is being improved. Improved chemical methods of treating the ore before "cyaniding," in order to remove the so-called "cyanicides," are being discovered and put into use, thus extending the list of ores to which the process can be applied. Improved mechanical means for subjecting the ore to the solution are being devised, thus shortening the time required for solution, or for charging and discharging the tanks, and, in general, greatly increasing the capacity of a given-sized plant. Improvements are being made in the solution itself, it being found that the judicious addition of oxidising agents, such as sodium peroxide, potassium permanganate, hydrogen peroxide, ozone, etc., to the solution increases notably the rapidity of solution and economises in potassium cyanide.

The Kendall process, which uses sodium peroxide, is already used successfully at half a dozen plants in the United States, and Mr. Kendall some time ago went to South Africa to demonstrate the benefit of this addition to the Transvaal proprietors.

Improvements are very much needed in the precipitating of the gold, and the patent offices bear record to the activity which exists in this direction. Chemicals are being discovered which precipitate the gold completely on long standing, such as mercuric chloride, zinc chloride, freshly precipitated copper sulphide, cuprous chloride, and others, and many of these are really promising; but their drawback is that they do not act in the presence of free potassium cyanide, which must, therefore, be first removed, thus complicat-

ing the method. A chemical precipitant which will work on the solution just as it comes from the ore is a great desideratum, and may possibly be discovered in the near future.

Last, but not least, of the improvements in the application of the process is the reduction in cost of treatment owing to the reduced cost of potassium cyanide. As has often happened in other fields, the demand for a chemical product has led to improved means of making it, and the cyanide industry has been no exception. Mr. Castner has his two large sodium works (1000 horse-power in Great Britain and 500 horse-power at Niagara) busy turning out metallic sodium, the larger part of which is being used to make sodium cyanide. The "cyanide" item in the expense account has been reduced one-half from this improvement alone, and again an immense circle of still lower grade ores has thus been added to the list of "suitables" for the growing process.

This is the keynote of the future of the cyanide process. As it stands at present, it needs, is capable of, and will certainly receive, many radical improvements; each improvement will widen the scope of the process in the double direction of making more difficult ores amenable to it and of rendering available lower and lower grade ores. Thus continual improvement and a greater application will be the future characteristics of the process.

SPEED AS AN ELEMENT OF WARSHIP DESIGN.

By Passed Assistant Engineer Walter M. McFarland, U. S. N.

IN every vessel intended for sea service the absolutely vital feature is mobility, which practically means speed, and this is just as true of warships as of others, although, at first, one might think that for the former the armament would be of primary importance. But a war vessel, unable to move, becomes simply a floating fortress, very useful still under certain conditions, but no longer truly a ship. This premise seems almost self-evident after a little thought, but we are then confronted with the all-important question, How great shall the speed be? A consideration of the conditions governing the answer to this question is the object of this paper.

First of all, we may say, leaving out of consideration for the moment vessels of the torpedo-boat type in which everything is subordinated to speed, that, in general, the speed is properly proportional to the size of the vessel—that is, to the displacement. There is a very sound reason for this, due to the fact that it is more economical per unit of displacement to drive a large vessel at a high speed than a small one. Any one who is at all observant, even if without a technical acquaintance with ships, must have noticed that, in the case of the transatlantic flyers, as the speeds have increased, so have the displacements.

The *Arizona*, the first of the "greyhounds," was a vessel of 17 knots average speed and 6400 tons displacement; the *Alaska* made 18 knots on 9200 tons; and this gradual increase passes through the *Paris* and *New York* of 21 knots and 13,300 tons up to the *Campania* and *Lucania* of 22 knots and 18,000 tons, and the *Kaiser Wilhelm der Grosse* of 23 knots and 20,000 tons displacement. The same thing is noticeable in unarmoured war vessels, where we have, in the United States Navy, The *Yorktown* class of about 16 knots and 1700 tons; the *Detroit* class of 19 knots and 2300 tons; the *Baltimore* class of 20 knots and 4500 tons; the *Olympia* of 21 knots and 5600 tons; and the *Columbia* and *Minneapolis* of 23 knots and about 7500 tons.

In a war vessel, the elements which make claims for a percentage of the total weight or displacement are, the hull proper, the motive machinery and auxiliaries, the fuel supply, the armour or protection, the ordnance and ammunition, the weight of the crew, effects and provisions. Roughly speaking, the first and last may be considered as fixed quantities or percentages, so that those admitting of adjustment are the other four, or three, if we count machinery and coal as a single item.

It has been often stated, and it is perfectly true, that a war vessel is a compromise, and a little consideration will show that we have three tolerably well defined classes:—

1st. Battleships, where speed (that is, machinery) is minimised to secure heavy ordnance and armour.

2d. Armoured cruisers, where armour is reduced to secure speed and heavy ordnance.

3d. Protected cruisers and gunboats, where speed is the dominant factor, ordnance is greatly reduced and armour almost disappears.

Experience has shown to a considerable degree what are the limits of the main classes, but in each class there is still room for a choice of the various factors, depending, to some extent, on the fad or whim of the time, but much more on the progress of invention in matters relating to naval vessels and to the talent and nerve of naval designers. Instances occurring to all are the great improvements in the design and manufacture of guns and explosives, and in the manufacture of armour. The improvement in armour has been so great that a modern plate of the best makers is equal to one of those of twenty years ago of double the thickness, and a similar statement holds with respect to guns and explosives.

In machinery, progress has been just as great, due to improved materials, better designs, and the perfection of inventions. The advent of steel for so many purposes, enabling higher pressures to be carried, fast running engines, forced draught, and water-tube boilers, have all combined to reduce the weight of machinery per unit of power, and this, in conjunction with the increased economy in the use of steam, has enabled engineers to put an amount of power into a ship which, twenty years ago, would have seemed incredible.

The whole tendency of naval design has been toward higher speeds for vessels of all classes, more marked in some than in others, but very perceptible if we compare the vessels of to-day with those of twenty or thirty years ago. The advantage possessed by the faster ships, other things being equal, in a naval engagement, is so obvious that it is natural for every nation to strive to avail itself of every improvement which will give it faster ships; indeed, speed is so highly prized by some designers that they are inclined to reduce other features somewhat to secure the highest speed.

The remark already made that the choice of the factors in the design of a ship is, to some extent, dependent on the whim of the time, was not written carelessly. This very question of speed is an illustration of it. Between ten and fifteen years ago there was a craze for high speeds all over the world, and every vessel was designed for the greatest speed that could be possibly got out of her. It was the time of the introduction of the light, fast-running engine and the renaissance of forced draught. So far did it go that engines were built entirely too light, and boilers too small, and the coal supply allowed was utterly inadequate. The sensible application of the principle of "big speeds for big ships" was ignored, and working vessels of the cruiser class were given speeds much higher than we now know to be useful and economical. The growth of sounder ideas is illustrated by the following table, showing three British vessels, of which the most recent, although nearly twice the size of the earliest, makes only half a knot more speed:—

	Magicienne.	Latona.	Hermes.
	1887.	1890.	1898.
Length, feet	265	300	350
Beam, feet	42	43	54
Draught, feet	17.5	16.5	21
Displacement, tons	2,950	3,400	5,600
Speed, knots	19	20	19.5
Protective deck, inches	1.5	2.0 to 1.0	1.5 to 3.0
Normal coal capacity, tons	400	400	550
Crew	218	273	450
Armament	VI—6 in. B. L. R. IX—6 pdr. Q. F. One 3 pdr. One machine gun. One boat gun. Two torpedo tubes.	II—6 in. Q. F. VI—4.7 in. Q. F. VIII—6 pdrs. One 3 pdr. IV—Mach. guns. One boat gun. Four torpedo tubes.	XI—4.7 in. Q. F. VIII—12 pdrs VII—3 pdrs. IV—Mach. guns One boat gun. Two submarine tubes.

We have seen that the speed can properly, and without detracting from the general efficiency, be made higher as the size increases, and we have seen what are the other factors that have to be considered in reaching a decision.

Let us now discuss actual figures for the speeds of the various classes of ships, noting what has been done in the various navies of the world, and what are the prospects for the future!

During the Civil War in America, the destruction wrought by the *Alabama* brought out the design and construction of two remarkably fast ships, the United States cruisers *Wampanoag* and the *Ammonoosuc*, which made speeds far ahead of those of any other vessels afloat, and which were not reached again for nearly fifteen years. The average speed of the *Wampanoag* for a 37-hours' run at sea in February, 1868, was 16.71 knots; the average for several 6-hour periods, 17 knots; and the maximum 17.75 knots. The machinery and coal absorbed 46 per cent. of the displacement, an amount that would now be considered excessive except in torpedo craft. but she accomplished perfectly the object of her design in being the fastest steamer in the world.

The United States cruiser *Minneapolis*, which, about twenty-five years later, earned the same title, made an average speed for four hours of 23.07 knots, and her machinery and coal were about 40 per cent. of the cruising displacement, which is just about twice that of the *Wampanoag*.

From the data already given it will be seen that appropriate speeds for unarmoured vessels may be considered about as follows:—

1000	tons	12 knots.
2000	"	16 "
3000	"	17 "
4000	"	18 "
5000	"	19 "
6000	"	20 "

Above this displacement the vessels would probably be intended, like the American *Columbia* and *Minneapolis*, the British *Powerful* and *Terrible*, and the French *Guichen* and *Château Renault*, for the special role of commerce destroyers, and their displacement and speed are adjusted so as to secure the highest practicable results, combined with a large coal supply. Thus far 23 knots are the maximum speed attempted.

In unarmoured vessels, the choice of factors in the design is comparatively simple, as protection has been almost wholly sacrificed; and, as they are not expected to fight armoured vessels, the ordnance is not very heavy. When we come to the class of armoured cruisers, the circumstances are wholly different. Here, all three chief factors are desired to have a fair representation, and there are many circumstances which affect the result.

In many cases, it is really hard to decide whether a ship should be classed as an armoured cruiser or as a battleship. The ill-fated United States ship *Maine*, when designed, was known as Armoured Cruiser No. 1; but, before her destruction, she had been classed as a second-class battle-ship. If we draw a rough line at 20 knots speed as a minimum and 6 inches of armour as a maximum for an armoured cruiser, then the *Maine* was properly a battle-ship. Even then, the ordnance should count, and it would seem that the Spanish vessels recently destroyed at Santiago, the *Oquendo* and *Maria Teresa*, with 11-inch guns and 12 inches of armour, should have been classed as battle-ships as well as the *Maine*, with her 10-inch guns and the same armour. The *Maine*, however, had a speed of less than 18 knots, while the Spanish vessels were credited with over 20, which, it may be said in passing, they did not make when Admiral Cervera tried to escape at Santiago.

In the armoured-cruiser class, however, speed is certainly the prime factor. It is recognised that such cruisers must have considerable protection and a powerful battery in order to be able to overwhelm vessels of the unarmoured class, but unless they have a high speed, these latter could escape, and therefore ordnance and armour are subordinated to speed. To be really efficient, these vessels must be large, and the displacement ranges usually from about 7000 to 9000 tons, although the Russians first, and now the French, are going in for greater displacements. The *Rurik* is 11,200 and the *Rossia* 12,195, while the *Peresviet* class are to be 12,500 tons. The *Jeanne d'Arc* is 11,270 tons, and

the *Montcalm* class (six in number) are to be 9500 tons.

The following table shows some of the more important armoured cruisers of various navies:—

Name.	Country.	Displacement Tons.	Speed, Knots.	Belt Armour, Ins.	Main Battery Calibre Ins.	Coal Supply, Tons.	Protective Deck, Ins.
Brooklyn	U. S	9,271	21.9	3	8	1,753	6
New York	U. S	8,200	21.0	4	8	1,290	6
Blake	Great Britain	9,000	21.0	--	9.2	1,500	6
Edgar	"	7,350	21.0	--	9.2	850	5
Gibraltar	"	7,750	20.0	--	9 2	850	5
Powerful	"	14,500	22.0	--	9.2	3,000	4
Diadem	"	11,000	20.7	--	6 Q. F.	2,000	4
Orlando	"	5,600	19.0	10	9.2	900	3
Jeanne d' Arc	France	11,270	23.0	6	7.7	2,600	2
Montcalm	"	9,500	21.0	6	7 7	1,025	2
Fürst Bismarck	Germany	10,600	19.0	8	9.6	1,000	3
Rurik	Russia	11,200	19 5	10	8	2,000	2.8
Rossia	"	12,195	22 0	10	8	2,500	3.0
Peresviet	"	12,560	20.0	10	10	2,500	2.8
Maria Teresa	*Spain	7,000	20.2	12	11 3	1,200	2.0
Colon	* "	6,840	20.0	6	10	1,000	2.0
Garibaldi	Argentina	7,000	20.0	6	10	1,000	1.5
O'Higgins	Chile	8,500	21.5	7	8	1,200	2.0
Maria Theresa	Austria	5,370	19.7	4	9.6	740	2.2
Varese	Italy	7,000	20.0	6	10	1,000	1.5

* Now belong to U. S.

It will be seen from this table that the majority of this class have speeds above 20 knots, and if we take the most recent ones it will be found to average about 21 knots. The *Jeanne d'Arc* is the only armoured cruiser thus far designed for 23 knots, but, judging from experience in naval designs, it would not be at all surprising if there were shortly a lot of 22-knot armoured cruisers in the different navies.

In the battle-ship class, as has been pointed out, speed is subordinated to ordnance and armour, or, in other words, the maximum speed is much lower than in the class of armoured cruisers. The tendency here, however, as in the other classes, is constantly toward higher speeds. As a rule, in vessels of this class, this has resulted from, and been made possible by, the improvements in machinery which have steadily increased the output of power per unit of weight, as the weight of machinery is generally a decreasing function of the displacement.

The old idea of battle-ships was that they were to be able to stand an indefinite amount of pounding from the heaviest guns and to return the compliment, so that speed was considered of secondary importance, but the march of progress has changed this idea considerably. The advent of the armoured cruiser class, with guns almost as heavy and armour of respectable thickness, but with speeds of three and four knots greater, has made it absolutely necessary to raise the speeds of the battle-ships if they are to be capable of engaging anything except vessels of their own class.

Twenty years ago the majority of battle-ships had a speed of 14 knots; this has gradually increased until the standard speed may now be put at 18 knots. As far as can be ascertained, no first-class naval power is now designing any battle-ship for less than 18 knots, while in several cases speeds as high as 20 knots are contemplated. About a year ago, the battle-ship *Yashima*, of the Japanese Navy, averaged 19.23 knots on a four-hour trial. The *Sicilia* and *Sardegna*, of the Italian Navy, are credited with 19.6 and 20.2 knots, respectively.

According to the naval manuals, vessels of 18 knots or higher have been built or are building, as follows:—

Great Britain.

Royal Sovereign class (7)	18 knots.
Majestic class (9)	18 "
Barfleur, Centurion and Renown	18.5 "
Canopus class (9)	18.8 "

France.

Bouvet class (4)	18 "
Charlemagne class (3)	18 "
Iena, Suffren	18 "

Germany.

Kaiser Friedrich class (3)	18 "

Italy.

Lepanto, Umberto	18.3, 18.5 "
Sicilia, Sardegna	19.6, 20.2 "
Saint-Bon, Filiberto	18 "

JAPAN.		
Fujiyama	18.7	knots.
Yashima	19.2	"
Three building	18.5	"
RUSSIA.		
Sinope, Catherine II	19.3	"
Building at Cramps	18.0	"
CHILE.		
Capitan Prat	19.0	"

From this synopsis it is evident that a projected battle-ship, to be really first-class, must have a speed of at least 18 knots. It must be understood, of course, that the vessels in the foregoing list are by no means equal in all respects. Some have only 10-inch guns and 8 inches of armour, while the big "Royal Sovereigns" have 13.5-inch guns and 18 inches of armour.

If we are to have all three items of speed, ordnance and armour at a maximum, then we must have a very large ship. On a given displacement only a certain amount of weight can be assigned to each item, and if ordnance and armour must be a maximum, the speed cannot be high on a moderate displacement. It seems, however, from a study of a number of good examples, that a speed of 18 knots, combined with a sufficiently powerful battery and an excellent distribution of armour, can be obtained on displacements ranging from 11,250 to 12,000 tons.

While all naval experts agree as to the value of high speed for battle-ships, there is no agreement as to how far ordnance and armour can be reduced to secure it. One eminent naval authority recently maintained that it was little better than waste of money for a naval power nowadays to deliberately design and lay down any vessels which shall have less speed than vessels of corresponding classes in the navies of other nations.

On the other hand, one of the editors of *Le Yacht*, in commenting on the destruction of Cervera's fleet at Santiago, says:—

"The disaster of the Spanish vessels seems to condemn definitely, for important naval operations, the employment of vessels of the second class, in which speed is considered to compensate for the lack of ordnance or deficient protection. The Spanish squadron, theoretically, should have been able to play with the Americans. Constantly eluding pursuit, it should have destroyed single cruisers, intercepted convoys of transports, and spread terror on the American coast.

"Such is the constant illusion of the feeble or negligent who will not understand that the only way to conquer is to possess the force and the means necessary to meet the enemy face to face.

"Instead of this glorious, though less romantic role, the Spanish fleet has perished, and was not even able (supreme consolation of the vanquished) to return the blows it received. It could scarcely have been otherwise, and it will always be the same, when an inferior naval force finds itself in conflict with a superior, but slower one. The former, thanks to its speed, will at the first have some advantage; but a time will come when, in consequence of wear and tear, or accident, the speed will fail. Then will surely come disaster.

"Speed is, in fact, of all the military qualities of a war vessel, the most risky, the most capricious, and the one least to be counted on. Armour and coffer dams constantly protect the vessel. The guns do not lose their power. But for a vessel to make the same speed as on trial, or one near it, there must be a combination of circumstances exceedingly rare, and whose reunion is not under the control of human will and intelligence."

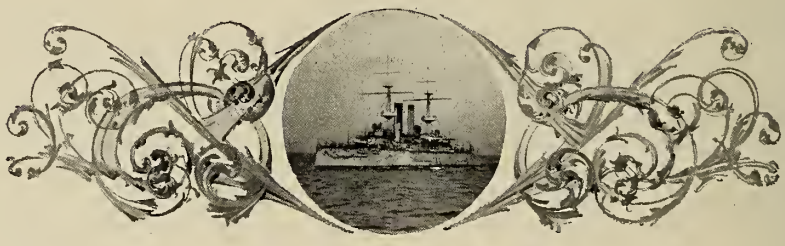
He continues on this line, showing that a heated bearing or an inefficient blower may ruin the speed, and alleges that too much depends on the personal element, which, under the trying conditions of the machinery compartments, is likely to fail.

To the writer's ideas, it appears that this proves too much, for it seems to assume that the regimen of the machinery on a battle-ship is much easier than on an armoured cruiser. A more intimate acquaintance with machinery would have taught him that the machinery of the slower battle-ship is worked just as hard as that of the faster cruiser,

and as far as loss of speed due to accidents is concerned they are on an equality. It is probable, too, that he had only meagre details of the engagement, and was not aware of the great part played by the *Oregon*, which was due almost entirely to her wonderful speed performance.

To most naval men, if any one thing has been demonstrated by the battle of Santiago, it is the vital importance of speed and of leaving nothing undone that will assure the maximum speed whenever wanted. All the reports go to show that the *Colon* had a chance of escape if the *Oregon* had not overhauled her. Owing to the system of premiums in vogue when the *Oregon* was built, her contractors worked for, and attained, a speed of nearly 17 knots, although only 16 were required, and her admirable engineering staff had kept the machinery in perfect condition. The result was shown at Santiago.

It is hoped that this discussion has shown that speed is a vital element in the design of every naval vessel, and that the maximum speed of all classes is slowly but constantly increasing. There is no finality to progress, and every nation is compelled to do at least as well as the rest, or fall out of the race. The highest speed gives the "weather gauge" to the modern war vessel, and, when this can be made a certainty, instead of a lucky chance, no nation can afford to neglect the means for its assurance.



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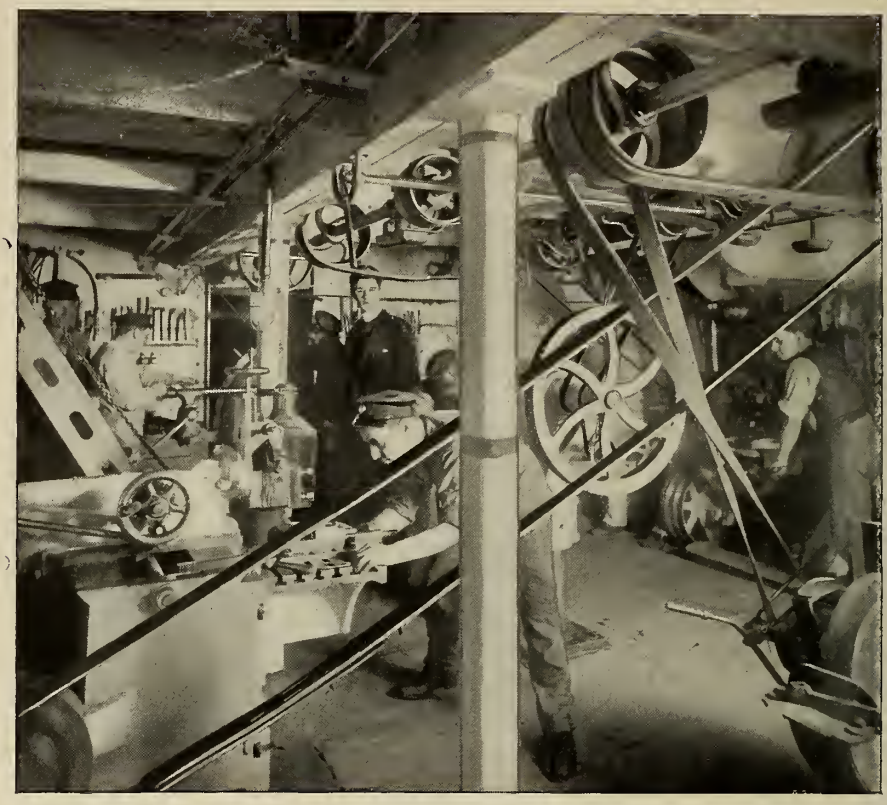
A MAN OF WAR'S FORGE.

NAVAL REPAIR SHIPS.

By Chief Engineer A. B. Willits, U. S. N.

AMONG the hundreds of thousands of Americans who have gazed with pride and admiration on the modern warships of Uncle Sam's Navy, as they lay at anchor in some quiet harbour or steamed in stately squadron, there are few, indeed, whose thoughts carried them beyond the outer evidences of power and speed and destructive force which seemed to fill the picture, and led them to the scenes of ceaseless activity and work which are hidden by the iron sides and covered by the guns. To tell them that these silent and swift bearers of huge death-dealing weapons are beehives of industry and never-ending toil within, scarcely would meet with credence, or, at most, would excite but passing interest, while the impression would remain that the life on board is as serene and watchfully quiet as it appears to be on deck.

Even after a visit to, and a thorough inspection of, a modern battle-ship in port, one carries away but a faint idea of the intricacy and quantity of the contained machinery, and none at all of the absolutely requisite amount of labour and material that is continually being expended in order to keep the ship in a state of readiness and efficiency. Just as the great enterprises in commercial life indicate but little to the general public the details of the toil and study which preserves them in permanently successful operation, so here it is not in line with the attitude of prowess to



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A REPAIR SHOP ON BOARD A BATTLE-SHIP.

parade the anxious oversight and the incessant exertions demanded by the internal requirements of a man-of-war in service.

In setting forth the value of a naval repair ship, it is especially desirable to pull this curtain aside and invite the reader's attention to the details of the assemblage of mechanical devices on board, in order that he may have a clearer conception of their magnitude and necessities, and be better able to appreciate the possible casualties and demands for repair.

A battle-ship is not only a floating fortress, but is also a steam power plant of the largest size, with a greater variety and number of engines or machines than is ever dreamed of by the uninitiated. Of all this combination there is no portion that can be permitted to remain in a state of repose for any length of time without endangering its effective action when the emergency arises for which it was designed. It is only by constant use that they can be kept perfectly efficient, and at the same time this continued practice is equally necessary in order to familiarise the men with the details of the operation of every part and thus secure that prompt and certain response in time of action without which success is jeopardised to a degree difficult to overestimate. Besides this there is a value in continually trying important mechanisms which lies in the discoveries of the little defects by correcting which greater improvements and advances are made in construction and design than is possible from the mere study of the plans.

From this it is seen that even in times of peace, warships are cruising over the seas, keeping their various machines in constant use as the best method of keeping them useful. Of course, it is not

difficult to understand that all this involves constant wear and tear, which can be compensated for only by as constant repair.

Steamships of the great transatlantic lines run practically from repair shop to repair shop, as, at each end of the route, on arrival, a gang of mechanics stands ready to jump on board and take the matters requiring attention in the machinery department in hand immediately, working night and day, so as to have the ship ready to sail at the appointed time. It is for this reason that we hear so little of the necessities of these ships in this line, while when it becomes necessary to send a man-of-war to a navy yard, the fact is made prominent in the daily papers and adverse criticisms are invited from those who really know little about it.

After even a week's run, or the time needed to cross the ocean, the big merchant ships have often an enormous amount of overhauling to do, while in repairing the more serious breakdowns, the terminal stations rush the work through in short order by having spare parts of machinery always at hand to substitute for the damaged ones. To have this supply for naval ships at all large yards would be impracticable, and, therefore, delays are with them far more numerous and necessary when they have met with a mishap which requires renewal of parts of any size.

All naval ships have machine shops on board and skilled mechanics also, but the shops are necessarily very small owing to the mass of material and the quantity of machinery a warship has to carry and, at the same time, afford accommodations for the hundreds of men and officers which form her complement. Hence, it is only by the greatest effort that the ordinary running repairs are kept in hand and prevented from accumulating to the point of delaying the ship, while on the occasion of casualty there is nearly always more economy in the matter of time saving, in sending the vessel to a navy yard than in trying to make the repairs by the force on board. Of course, some very heavy and intricate work can be done on the ship, but the limited space and facilities for handling it makes it tedious and less satisfactory, while the manufacture of any large part, to replace one broken, is nearly impossible without the assistance of the tools of a large shop.

Let us look at the list of engines on an armoured cruiser, like the *Brooklyn*, of the United States Navy, taking her as a sample of an up-to-date warship, between a battle-ship and an ordinary cruiser. On this ship the following is the number of different machines having steam cylinders for their operation:—

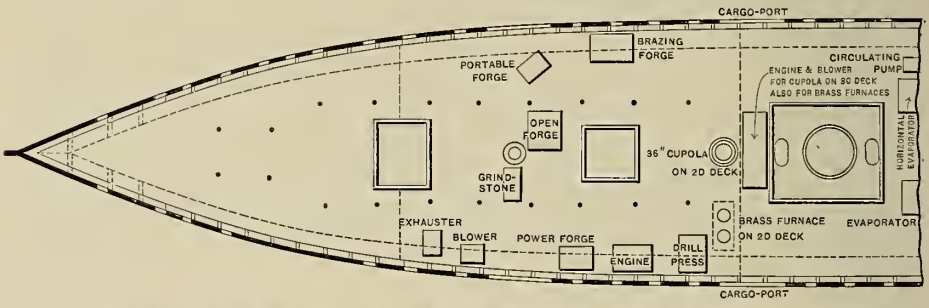
4 main engines having a total of	12	steam cylinders
4 main air pumps	8	"
4 main circulating pumps	4	"
2 auxiliary condenser pumps	2	"
4 water service pumps	8	"
4 fire and bilge pumps	8	"
4 turning engines	8	"
4 engine room ventil'ng blowers	8	"
7 feed pumps	14	"
12 fire-room blowers	24	"
6 ash hoists	12	"
1 ice machine	1	"
1 workshop engine	1	"
4 distiller and evaporator pumps	6	"
1 windlass	2	"
2 boat cranes	4	"
3 deck winches	6	"
2 turret turning engines	4	"
1 steering engine	2	"
4 dynamo engines	8	"
4 ship's ventilating blowers	8	"
1 oil pump	2	"
2 steam launch engines	4	"
81 engines.	156	"

Add, in imagination, to this list, imposing in itself, the vast quantity and extent of steam, exhaust and water piping needed to connect all these engines to the boilers, condensers and water systems; the thousands of valves to be kept workable and efficient! Then include the seven great boilers, capable of evaporating into steam, under forced draught, 185 tons of water an hour, and the reader can begin to comprehend the vastness of the steam plant of a modern ship.

The boiler work alone, absolutely requisite to be done to keep these generators in excellent condition, is enormous and obviously of the greatest importance. In fact, one of the peculiarities of repairs on shipboard is that each item, however apparently insignificant, is vitally important, as each part is so dependent on the fitness of the others as to make the breaking of a very small attachment sufficient to render, at times, one of the main engines unserviceable.

In view of these facts, the engineer-in-chief of the United States Navy has had for some years the preliminary plans for fitting out a floating navy yard, as far as machine shop facilities for repairing machinery is concerned, believing that the value of such a repair ship would be incalculable in times of war. The peace which the United States enjoyed for so long a time caused the actual completion of this type of vessel to be deferred, as the widely scattered state of the ships of the various squadrons made it difficult to properly utilise this method of attending to their wants with any approach to economy, and besides this there seldom existed any serious reason for keeping a disabled ship away from the navy yards; feet, 6 inches aft. Her carrying capacity was about 2700 tons. This tonnage must not be confused with the tonnage usually employed in naval parlance, as with war vessels no measured tonnage is given, but only the tonnage of displacement, which is the actual weight of the entire ship. The vessel was built by the American Ship-Building Company, of Philadelphia, Pa., in 1884, but had recently been fitted with entirely new boilers, which, with the repairs put upon the machinery or engines, made that department excellent in spite of the age of the vessel.

The engine is a compound, vertical, direct-acting one, with a high-pressure cylinder 40 inches in diameter, low-pressure cylinder 72 inches in diameter,



FORWARD HALF DECK PLAN OF THE UNITED STATES REPAIR SHIP "VULCAN."

while, on the other hand, it was good policy to have them visit these shops periodically in order to keep the workmen there somewhat familiar with their requirements and the best methods of handling the repairs.

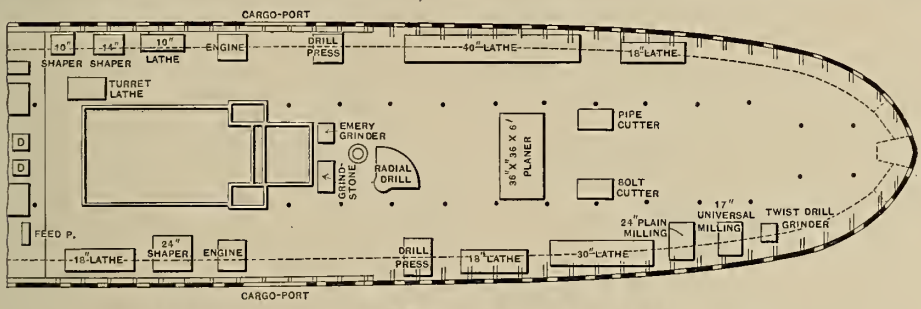
When, however, the United States began buying merchant ships with which to form an auxiliary navy for use in the war with Spain, Commodore Melville seized the opportunity of selecting a suitable vessel to transform into his desired repair shop, and the one taken was the *Chatham*, of the Merchants' and Miners' Line, the name being at once changed to *Vulcan* in anticipation of the character of the work she was to do.

The *Vulcan* is a single-screw ship, 265 feet long, with 40 feet beam, and 26 feet depth of hold, and had a load draft of about 17 feet forward and 20

and a stroke of 48 inches. The main air-pump, and also two feed pumps and two bilge pumps, are attached to the main engine, but the main circulating pump is independent. There are four main boilers and one auxiliary boiler, and the cruising economy is about 25 tons of coal per day at a speed of 12 knots. She is a good sea boat, stiff and able, and in every way fitted for this important purpose.

To prepare her for service she was sent to the Boston Navy Yard, where, under the supervision of experienced engineers, and by dint of the energy and push of the engineer-in-chief, she was quickly converted into a modern workshop, with all the facilities for coping with almost any kind of repair work that could possibly be anticipated. This was accomplished in such good time that the *Vulcan* reached the United

States squadron off Santiago in time to be "in at the death" of Admiral Cervera's fleet, and to be of the utmost service to the United States ships there at that time. Directly she was the means of keeping the ships together, as there is no doubt that several, otherwise, would have had to go to Key West for needed repair work. The promptness of her arrival and the comfort she administered in a mechanical way were such as not only to cause the most favourable comment in the fleet itself, but also to demonstrate in the most satisfactory manner to the Navy Department, and especially to the Bureau of Steam Engineering, the success of the plan, and that with her a new feature of the greatest prominence,



AFTER HALF DECK PLAN OF THE UNITED STATES REPAIR SHIP "VULCAN."

permanence and value has been added to the Navy.

The general character of the *Vulcan's* plant can best be appreciated by a résumé of the different tools and appliances, which is, in a general way, about as follows:—

Machinists' Tools.

One gap lathe, 40 inches swing, 20 feet between centres.

Two lathes, 30 inches swing, 10 feet between centres; each of the above fitted with a boring bar with travelling head.

Four lathes, 18 inches swing, 6 feet centres.

One lathe, 12 inches swing, 4 feet centres.

One small monitor lathe.

One planer, to take 4 feet square, with 10 feet travel.

Two planers, to take 3 feet square, with 5 feet travel.

Three shapers, 10 inches, 14 inches, and 24 inches stroke.

One radial drill, to drill at 48 inches from side of column.

Two drill presses, 3-inch spindle, to drill up to 1½-inch hole and with 12 inches vertical movement.

Two drill presses, 2-inch spindle, to drill up to 1-inch hole.

One bolt-cutting machine, with standard taps and dies to cut from ½ inch to 2 inches, varying by 1-16 inch.

One pipe threading machine, to cut from ½ inch to 4 inches, with standard pipe-taps and dies.

There is also a complete set of cutting tools, dogs, chucks, angle plates, clamps for each power tool, together with all attachments and fittings complete, including counter shafts, pulleys, etc. The regular outfit of belting, pulleys and line shafting, with universal couplings, self-oiling hangers and modern fittings, were installed, as in the best machine shop ashore, and in this part of the ship were also placed emery tool grinders, with a complete set of attachments and the regular grindstones found in all shops.

Foundry Outfit.

One 36-inch cupola of most improved design, to melt 3000 pounds metal at each tapping. A blower and engine to furnish blast; hoist, piping and fittings complete.

One furnace, iron-lined, with fire brick, to take three 100-pound crucibles, funnel about 12 inches diameter.

Three sets crucible tongs, 1 set for each size of crucible.

Fifty crucibles, of 50 pounds capacity.

Fifty crucibles, of 100 pounds capacity.

Three crucible bearers for each size crucible.

Three complete sets of moulders' tools.

Coppersmiths' Outfit.

One brazing forge, with two circular and one long fire, for blast, to be built up in light iron and lined with fire brick.

One set of tools, including shears, stakes, hammers, beck irons, blocks.

Three tinsmiths' furnaces, with soldering irons, pots, etc.

Blacksmiths' Outfit.

One open hearth forge, 5 feet in diameter, with cowl and 12-inch funnel, to be built up of brick and iron, used for heavy forging or flange turning, to be fitted for power blast.

Two forges, with power blast, to weld 4 inches square (16 square inches).

Two forges, portable, with hand blowers to weld 2 inches square.

One Sturtevant pressure blower, to be driven by engine attached; a quantity of 3-inch and 2-inch light iron pipe for leading blasts.

Three portable hand blowers, 14-inch fans, driven by levers.

Six anvils, with blocks, two of 150 pounds, two of 180 pounds, and two of 200 pounds.

One complete set of forge tools with each forge.

One surfacing plate.

Six swedge blocks, 200 pounds each.

One welding block, about 6 inches square and 4 feet long, with three grooved sides, the grooves 2-inch, 3-inch and 4-inch die.

Twelve hand hammers.

Six flogging hammers.

Six sledges; two 6 pounds, two 8 pounds, two 12 pounds.

Boilermakers' Outfit.

Fifty boilermakers' kits, including hammers, chisels, caulking tools, drift pins, reamers, scrapers, etc.

Twelve sets rivetting hammers, 8 sets straight pene, 4 sets ball-pene.

Twelve sets roller expanders, from 1¼-inch to 3-inch, varying ¼ inch.

One power punch and shears, single machines, 15-inch throat, to punch 1 inch in ⅞-inch plate and shear 15 inches by ⅞ inch.

One set hand rolls, to be set on upper deck, rolls to be 6 inches diameter by 6 feet long.

Six rivet-heating forges.

One dozen boilermakers' ratchets, short, with square shank drills.

Sixty each of the following sizes of square shank drills:—½-inch, ⅝-inch, ¾-inch and ⅞-inch.

Six tube cutters, to cut from 1½-inch to 3-inch tubes.

One dozen flogging hammers, 4 pounds.

One dozen sledges, 8 pounds.

Six clubs and sledges, for holding on.

Six screw punches.

An abundant supply of material of every kind, for use in each of these trades, and engineers' stores in great variety, were taken on board, both for use in work and for issue to ships in need of replenishment.

To operate this plant it was necessary to obtain men of the most reliable character and of known experience, as there would be no opportunity to try them and exchange at leisure. The list of men secured was limited to the following number and class:—50 machinists, 25 boilermakers, 6 coppersmiths, 6 blacksmiths, 40 helpers, 4 patternmakers, and 6 moulders.

While the machinists' work would naturally be in preponderance, there is no more important item in the list than that of the moulders. The ability to make large castings afloat is a feature entirely novel in the navy, and yet the lack of such ability has been the direct cause of compelling many a ship to return to a navy yard when she was otherwise in every way ready to make a cruise. Very much of the machinery depends for its support upon castings, either of composition, steel, or iron and besides this many very important repairs can be made to parts which are not cast, by

fitting suitable brackets or embracements of cast material. With the patternmakers to get out the proper shapes, the moulders can quickly do their part, and, guided by the ingenuity of the engineer in charge of the work, an almost hopeless condition of affairs can be made secure and operative.

Many people will find some difficulty, in spite of the descriptions herein given, in imagining just what these repairs are that form such an important part of the maintenance of a fleet of ships in efficiency. They can readily conceive of a boiler bursting, but that happens to be one of the most remote contingencies, and is scarcely ever seriously considered, in present steam engineering, as among the ordinary possibilities. Not that many accidents do not occur in connection with these high-pressure generators,—but actual serious rupture of a boiler is rare, indeed. There is one trouble, however, which has developed into quite an ordinary one in the boilers of the ships of the fighting squadron off Cuba, and which the *Vulcan's* facilities are of great value in overcoming, and that is what is called the " coming down " of the furnace crowns.

The present war experience has shown most graphically the importance of having on every ship an amply large evaporating plant with which to make up all losses of fresh water for boiler use, and it has proved, beyond question, that the modern war vessel, generally speaking, is sadly deficient in this particular. When occasional visits to port are possible, where a good supply of fresh water can readily be obtained, the evaporating and distilling apparatus, as ordinarily installed, have been sufficient; but blockade duty, for months at a time, with no such additions possible, has brought to light the fact that the daily loss rapidly increases until it becomes far in excess of the supply. This is due to the increase in the minor leakages about the steam plant, which, under the conditions of constant steaming, are impossible to always reduce or stop, and, as a consequence, salt water has to be used in various quantities,—sometimes to such an extent as to incrust the crown sheets of the boilers heavily.

This has caused overheating, and in several instances these crowns, becoming red-hot, have been pushed down, or bagged, as much as 12 inches from the original line. The wonderful quality of the metal of which they were made alone prevented their actual rupture. When such an occurrence takes place, it is no longer safe to keep fires in that furnace, although with a reduced pressure the boiler could still be used with fires in the other furnaces.

To make proper repairs in such cases, steam must be taken off the boiler, and, using cast iron formers, made to suit the curve of the crown and the corrugations of the furnace, the metal is heated to a cherry red, and with hydraulic jacks of about 10-ton power the sagged portion is jacked back into place. The excellent mild steel used in boiler construction of the present day shows to great advantage here, and the replaced furnace crowns, as a general thing, show no permanent injury. If the metal has been badly burnt, this repair may be impossible, but this is not the general rule.

Such accidents as that of collision have also given work for the *Vulcan*, the force of the repair shop having made good and speedy replacement of injured plates in one instance, thus avoiding the necessity of sending the ship to a yard.

Broken cylinder covers can be replaced by new ones cast on board the *Vulcan*. Forgings for new piston rods or valve stems can be made and the work properly machined. Large bearing brasses can be cast, and the work of relining these can be easily and perfectly accomplished.

Heavy rock shafts, or any such large parts which may have been sprung or injured, can be swung in the large lathes of the repair ship and properly trued up. Piston rings can be cast and turned, as on shore; pump cylinders can be bored out and refitted quickly; copper pipe, burst or impaired, can be renewed by making other sections, up to

large sizes; in fact, copper pipe work is something always in demand, and one of the first items of work taken up by the *Vulcan* after her arrival in Cuban waters was to replace some sections of steam pipe destroyed in action off Santiago.

Keeping this floating shop well supplied with material with which to work, there is little that occurs in way of casualty of which she will not be able to take care. More ships of the same character will find ample field for service which will save the government far more in money for repairs than can now possibly be estimated, and, at the same time, having such a vessel attached to every squadron will give an assurance of being able to keep the vessels of a fleet together and always ready for joint action when wanted.

Nothing can be more disappointing and humiliating to the commander of a fine ship, and to his subordinates, than to be compelled to trickle back to a navy yard just when the country is expecting to hear of her effective work in some anticipated action. The people generally cannot understand the necessity for such return and have little sympathy for the commander. This is why the advent of the *Vulcan* at Guantanamo caused such rejoicing in the United States fleet. All were eager to stay on the ground and see the war out, and the speed with which the repair ship was prepared and sent to the scene of action, as well as the excellence of her complement for running the shops and handling her fine outfit, will ever reflect the greatest credit upon the framer of the plan and all who aided in its consummation.

SIR NATHANIEL BARNABY, K. C. B.

A Biographical Sketch.

SIR NATHANIEL BARNABY, late Director of Naval Construction and President of the Council of Construction of the British Navy (1870-1885), was appointed to his first independent office in 1854 when he superintended the construction of Her Majesty's ships *Viper* and *Wrangler*, at Messrs. Green's yard at Blackwall.

From 1855 until 1885 he was engaged in the designing and building offices of the Admiralty at Somerset House, the Dockyards and at Whitehall. His succession to the chief office in 1870 was unexpected and unsought by him, and he found the inheritance to be by no means a happy one.

The loss of H. M. S. *Captain* immediately after the retirement of Sir Edward Reed and before he was himself appointed to the succession, brought on a most important inquiry into the principles of the designs of all recent ships of war. Then followed a general naval protest against what were called low-freeboard ships, such as the *Glatton*, the *Cyclops*, and, more especially, the *Devastation*. These had been designed and partly built by Sir Edward Reed, and were completed after his retirement.

The Committee on Designs, which conducted the inquiry referred to above, supported the Construction Department in their views as to these ships. The contributions to naval science made during this inquiry by Professor Rankine, Sir William Thomson (now Lord Kelvin), Mr. William Froude, and Mr. Crossland, then one of the assistant constructors of the British Navy, were of high value, and from the loss of the *Captain* came a new and powerful impulse to the scientific study of shipbuilding in Great Britain.

Then followed the stranding of the *Megæra*, an old iron storeship Into this inquiry was made by a Parliamentary committee. It was said that the

administration then in power was economising by improperly using ships after they were known to be past service. Which political administration was charged, and which made the charge, may be easily guessed by those who know British political ways.

Resulting largely from the recommendations and inquiries of the committee on designs several new types succeeded one another in the subsequent years. The *Alexandra*, *Temeraire*, *Nelson*, *Inflexible*, *Colossus*, *Polyphemus*, *Iris*, *Comus*, *Calliope*, *Mersey*, *Scout*, *Rattlesnake*, *Imperieuse*, *Undaunted*, *Collingwood*, *Benbow*, *Howe*, and *Sans Pareil* represent varied types introduced between 1870 and 1885. During part of this time the Admiralty had the invaluable assistance of Mr. George Reudel as a member of the board. The controllers of the navy were two men of the highest type which the navy trains—Rear-Admirals Sir William Houston Stewart and Sir Thomas Brandreth. The first sea lord for most of the time was another of the Sea Paladins of England, Sir Astley Cooper Key.

In 1876 Sir Nathaniel Barnaby was at issue with Mr. T. G. Bowles concerning the privateering policy which was supported by "the Maritime League for the Resumption of Naval Rights," of which league Mr. Bowles was a prominent member. Sir Nathaniel circulated a pamphlet (marked for private circulation only) upon the changes which time had wrought in the character of shipping since privateering was in operation. In this pamphlet he showed that the Declaration of Paris of 1856 not only did not lessen the power of a great commercial marine, but increased it. Mr. Bowles published it in *Vanity Fair* without authority and said some smart things about it. In the pamphlet Sir Nathaniel said:—

"In the wars of sixty years ago the properly armed merchant ship was a fair match for the ship of war of her own size, but now the proportions, the structure, and the disposition of the machinery of the merchant ship make it impossible that she could fight successfully single-handed with a ship of war approaching her own size. If, therefore, privateering were admissible, it would have to be confined to ships which could save themselves by their speed if they met a ship of war, whether armoured or not; and British owners could employ only such of their ships as privateers as possessed a high sea-going speed. It must, therefore, be remembered that to talk of covering the seas with British privateers is to delude ourselves.

"Not more than 400 to 500 existing ships at that date (1876) or now possess the necessary speed either for privateering or for carrying on trade without being convoyed.

"Let us then," it was said, "consider whether it is not possible under the new rules to avail ourselves of these 400 to 500 ships—this really useful part of the ocean-going merchant navy of Great Britain, in such a manner as to avoid the terrible losses to the home and colonial owners of the slower steamships and the sailing ships which would result from the operation of the old rules under the modern circumstances of naval warfare!

"Let us suppose that on the outbreak of a war the State came into immediate possession, by purchase, of this fleet of 400 to 500 fast ships, or of as many of them as had complied with the State regulations as to fitness for warfare, such regulations being so framed as to be consistent with commercial success in ordinary times!

"During peace the owners will have benefited, as neutrals, by the quarrels of their neighbours whose property has been carried in the neutral ships. Should war come, the people at large reap the benefit of the new rules, and they take over at a valuation this fleet of ships. The nominal outlay would be, say, £20,000,000 to £30,000,000.

"The war navy would be immediately strengthened by the addition of ships capable of mounting a few guns, of ramming, and employing torpedoes. With this fleet she would exceed the power of her enemy, not only in proportion to the strength of her war navy, but in proportion also to the strength

and excellence of her mercantile marine, the élite of which would have been incorporated with it. With this navy she could close up every hostile port, and the slow steamers and the helpless sailing ships might cross the seas in such security (privateering not being admissible) that merchandise would be as safe in the British ship as in the neutral. Under these circumstances the colonies need hardly know that a war was in existence."

Eight years after the foregoing was written and published, it was found to be possible, in the prospect of war with Russia over the Penjdeh trouble, to get command of all the suitable fast steamships then at home or in colonial waters.

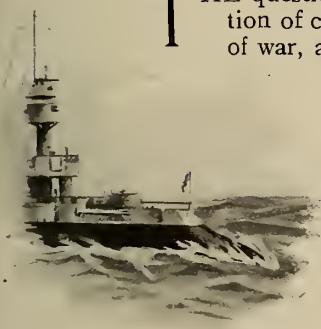
With these views Sir Nathaniel devoted many years to the endeavour to get better bulkhead division in fast merchant ships, twin screws in such ships, and an arrangement of coal armour. On this account, too, he advocates a distinction in the Board of Trade certificates between ships that have State value and those which have none. At present there are owners, like Mr. Thomas Ismay, and others who have slowly and reluctantly followed his example, who allow their builders to make provision for security such as a ship would need if brought under fire, so far as bulkhead division is concerned. Sir Edward Harland did this many years ago for the White Star ships, but such ships get no better certificate than the meanest sea carrier which the Board of Trade surveys. Board of Trade certificates protect badly divided ships to the injury of the more costly, well-built and well-manned ships. There should, he contends, be Pass certificates and Star certificates distinguishing between ships which are useless and those which would be useful for State service. For the same reason he advocates the foundation of national elementary nautical schools at the seaports in Great Britain and in the colonies, the schools to be free and without restriction as to the manner, or the country, in which the scholars will use their elementary knowledge and training. He considers that the cost would be less than the expenditure upon a single first-class ironclad, and would be infinitely more serviceable to the State.

Unhappily, these views are, he finds, most unwelcome to the officers of the Royal Navy. They do not appear to care how the mercantile marine is built so long as the State fighting ships are larger, faster, and more numerous than those of other nations. They seem also to disregard the rapid denationalising and degradation of the crews of British merchant ships.

PROTECTION OF BRITISH COMMERCE IN WAR TIME.

By Rear-Admiral Lord Charles Beresford, C. B., M. P.

To err is human. No better apology than this could be offered for a deplorable mechanical error which entered into the make-up of Lord Beresford's article in the July number of CASSIER'S MAGAZINE, and through which more than a page of text was bodily dropped out from the middle of his discourse. What was originally a most admirable exposition of the subject of protecting British commerce in war time was thus crippled to a degree of almost entire disconnectedness, and the article is, therefore, reprinted in this number, complete, without, however, reproducing the illustrations. The gap in the article occurred between the twentieth and twenty-first lines, counting from the top, in the left-hand column of page 213. Apologies are due to Lord Beresford, and to the readers of this magazine as well.—THE EDITOR.



THE question of the protection of commerce in time of war, as applied to the British Empire, is a very much bigger one than is at first sight apparent, and involves far more careful thought and organisation beforehand than most people who talk and write about it imagine. There is first the question of what we have to defend. It is not merely the welfare of British trade and commerce, representing, as some suppose, the possible loss of so much money, which is at stake. There is the still more vital question of defending British food supplies and feeding the people. It is a matter of avoiding possible starvation. In war between Great Britain and any other power or combination of powers, unless Great Britain can secure the certain and punctual delivery of both food stuffs and raw material, the country, and the working classes particularly, would suffer first from want of food, and secondly from want of wages, as, failing the raw material, almost all industries would be affected directly or indirectly, and the interdependence of the various forms of labour would be at once recognised.

Before going into the question of the probabilities of attack and the means of defence, it would be well to ascertain what Great Britain has to defend. British trade, represented by imports and exports, is valued in round figures at £800,000,000 a year, but this does not represent the sea-borne commerce of the British Empire. If we add to it the value of mercantile shipping, the British coal in ships' bunkers, and the bullion and securities passing to and fro, we find by the most careful calculations that the sea-borne commerce of the British Empire may be reckoned at 2000 millions sterling. This is the money value, and it represents exactly two-thirds of the total maritime interests of the whole world.

In 1801 the population of the United Kingdom was only 16 millions, and only 1 in 23 was fed on sea-borne food. Today, with a population of nearly 40 millions, over one-half depend on sea-borne food, *i. e.*, 1 in 2, instead of 1 in 23, and more than three-fourths of that population are dependent upon the steady and continuous supply of raw material for their daily employment. Great Britain imports £20,000,000 of foreign wheat and 8½ millions sterling of foreign wheat and flour every year, taking normal prices, besides 11 millions sterling of other cereals.

These figures exclude 2 millions sterling of wheat, about a million sterling of flour, and three-quarters of a million sterling of other cereals imported from India and British colonies. Butter, eggs, cheese, lard, beef, bacon and hams, mutton, pork, and live cattle, fruits and vegetables, are imported in equally large quantities. As a nation,

we stand unique in the history of the world for our entire and utter dependence on outside sources for the means of feeding our densely populated country. Our commerce is both the source of our wealth and the origin of our weakness. We are vulnerable in the very part of our system from which our greatness springs.

There are one or two points that I wish to drive home on this subject before going further. The first is that it must be noticed that the great increase of our population, and the greater increase of our dependence on sea-borne food and raw material, has all come since our last great naval war. It is a startling fact that we have no data of any sort, description, or kind upon which to base our ideas of the protection of commerce in the next great naval war. The conditions under which we lived at the beginning of the century, and the conditions now, are so changed that we can argue only in the dark on the probable effects of war.

The second point is not less important. It is that in the great warlike period of the end of the last and the beginning of the present century we lost (*vide* Norman's "Corsairs of France") 10,871 British vessels, captured between 1793 and 1815. This was during the period of our great naval triumphs, and represented the losses of a successful war. It lends a strength to a very old contention of mine, viz., that the price of victory may be a very dear one to a country like this, and that the losses inseparable from a successful campaign will be enormous.

The third point is that the naval strength of other powers is stronger relatively to our own than it was in our last great naval war, and certainly the prospects of a strong coalition against us are not less than they were in the Nelson period.

Having studied what we have to defend, the dependence of our population for wages and food on our commerce, and the historical teachings of the past as to the dangers of preserving intact larger interests, our next steps are to consider the possible line of attack, and the strategy which is to meet and successfully evade or repulse such attack, if our mercantile interests are not to be ruined in war.

It is well to remember that while the chief aim of our military shipping will be either to blockade the enemy in his own ports, or to induce him to come out, and then to capture or destroy him at sea whenever or wherever found, there is to be considered the larger duty of protecting commerce by direct means. It will not be sufficient for the navy to blockade and fight the enemy, because if this alone were done, the damage which might be inflicted on our commerce by one or two cruisers which got out, on to the trade routes, would be simply incalculable. The danger from cruiser attack in the blue water, and of torpedo attack in the narrow seas, are the two great elements of danger which we have to face in defending commerce

With regard to the narrow seas, the French have ten torpedo stations between Dunkirk and Morlaix. There is no point between the south of England and the north of France that would be beyond the "radius of action" of torpedo-boats from one of these stations. On the west of France there are eight torpedo stations of a similar character, in railway communication with those on the north, and provided with proper apparatus for carrying the torpedo-boats.

To the east of Gibraltar the French have sixteen torpedo stations, four in Algiers and Tunis, four on the coast of Corsica, and eight on the southeast coast of France, their radius of action extending from Gibraltar to Malta. Another noteworthy point is that the French torpedo stations are properly organised and equipped. Ours are merely adjuncts of busy dockyards, and lack that careful attention to details which characterises the French stations. These have all sorts of appliances, machinery, spare gear, and a properly trained personnel.

I am aware that the objection has been raised that international rules would scarcely allow of a torpedo-boat

attack upon the mercantile marine during war. International rules, which may be observed when insignificant powers quarrel and there are all the great powers to look on, and perhaps to interfere, are likely to be much more elastic when the greatest naval power—ourselves—is opposed to a coalition of two or more of the next greatest powers. In other words, there is no possible chance of securing the recognition of so-called international rules and usages in warfare unless the parties to the quarrel are overawed by a possible combination stronger than themselves, or the fear of reprisals acts as a deterrent. Apart from this, the torpedo-boat argument is very weak, in my opinion, because if it is permissible for a cruiser to destroy commerce by means of torpedoes,—a right which no one seeks to deny,—it is on the face of it hardly likely that the right could be denied to the torpedo-boat pure and simple.

With regard to the second point, as to cruiser attack in blue waters, a foreign programme of strategy which lies before me as I write, points out that "to have Great Britain at our mercy, it suffices to starve her by intercepting and hitting her enormous mercantile fleet which carries the treasures of the world; it suffices to starve her by stopping the packet boats that supply corn from foreign lands. These long files of cargo boats generally take the same course, routes that are known to all navigators, each of these ships recognises, in its turn, certain capes, that serve as landmarks on their way. It is, therefore, easy to overtake them on their usual route or at their landing-place."

This plan of attack will undoubtedly be adopted by any power opposed to us, and it will be the damage done before we are ready that will be the worst. Skippers are very nervous people, and the frightful losses which our mercantile marine is, at present, likely to suffer upon the outbreak of war, would send up insurance rates to a prohibitive figure, deter shippers from sending cargoes afloat until our navy had achieved some striking success, and these two items would so operate as to cause an immediate and alarming rise of prices in this country directly war was declared.

It will be seen, therefore, that the solution of the problem how to meet these dangers lies entirely in the question of adequate organisation before there is any probability of war. A definite system of keeping open the line of communication must be laid down. The Admiralty part of the plans for the mercantile marine in time of war ought to be cut, dried, and pigeon-holed, ready for use. To the best of my knowledge and belief, there are no such plans, except of the most elementary character. There were none in 1888, and it is unlikely they have been made since The dangers are undoubted. Will Great Britain, in the face of these dangers, remain unprepared?

A great many people underestimate the difficulties of the position, owing to the great apparent superiority of this country in point of numbers of cruisers; but it must be recollected that Great Britain will require a great many more cruisers in proportion. In connection with the military shipping we have a much larger fleet than any other nation, and a greater number of cruisers will be required to act as scouts and linking ships. Besides that, we want cruisers all over the world to attack and destroy the enemy's cruisers, and to defend our commerce.

The enemy will attack our mercantile marine with cruisers, auxiliary cruisers, etc., and not with battle-ships. The duties of our battle-ships will be to look after the battle fleets of the enemy, and therefore we must meet like with like, and cruisers must be detached to all parts to defend the trade routes, or, in other words, to keep open the line of communication. The line of communication in war time is everything, whether it is the communication between fleets, the commercial routes, or signalling. Lines of communication in war can be properly provided for only in time of peace.

Without careful organisation beforehand there will be a most hopeless state of confusion when war breaks out. The

Admiralty at a time of great pressure will be bombarded from all quarters by mercantile firms wanting to know what they are to do, and what measures are to be taken for their protection. Therefore, the Admiralty plans should be understood in the rough before war occurs. A general idea of the tactics of defence will not assist the enemy any more than it does to know that certain towns are fortified. The tactics of offence are quite a different thing, and must, of course, be secret. The Admiralty can, and ought to do much for the security of the mercantile marine, but I would impress upon private owners that they can do a great deal themselves by proper organisation and instructions to their captains in time of peace.

An elementary precaution which they could take would be to abandon the usual trade routes at the outbreak of hostilities, until such time as the Admiralty plans for defending those routes were adequate and in operation. The oceans are wide. We have seen in our own naval manœuvres, and now in the war between the United States and Spain, how easily individual ships, or even whole fleets, can be lost sight of at sea.

The elementary Admiralty plan ought to be clearly understood. In all my plans of campaign I have laid it down that at the outbreak of hostilities we should abandon for the moment the narrow sea route, *i. e.*, the Channel, Mediterranean, Suez canal, and Red Sea, for all commercial purposes. This would strike a severe blow at the object and utility of the torpedo stations. Our commerce should be sent by the blue water ocean routes, such as around the Cape. Our commerce inwards should be diverted to Bristol, and to London around the north of Scotland. The neck of the bottle, the entrance to the narrow seas, should be well patrolled by cruisers and torpedo catchers.

Last year, for the first time, the Admiralty showed signs of preparing a definite plan of campaign by initiating the fortification of the naval bases in the narrow seas at Falmouth, Lough Swilly, Berehaven and Scilly. This increases the radius of action of our cruisers and scouts, as they will now be able to coal at, or to retreat for protection, to these bases instead of going all the way back to Portsmouth or Plymouth.

Similarly, after years of agitation, the authorities are doing something at Gibraltar, which is our most important base, whether the Mediterranean sea or the Cape route is adopted. At all our colonial bases we should have modern cruisers laid up in reserve instead of at home. This disposes of the difficulty of transferring the crews in small and obsolete craft on our foreign stations. At present these ships would be useless. They are kept in commission for the sake of economy, but as their crews could neither come home after war, to man modern ships, nor the ships go out without visible means to find their crews, the policy laid down by the First Lord, when he was explaining away his manning difficulties, seems a very extraordinary and incomprehensible one.

The moment war is declared, a crowd of cruisers should be put to sea to protect the ports of arrival and departure of the mercantile shipping. There would be no difficulty as to this, in this country, but as I have shown, it is otherwise in our colonies, whereas if we kept modern vessels in reserve on these stations, not only would they be available for commerce protection, and for warning incoming vessels after a declaration of hostilities, but also for training colonial reserves. The colonies where they were stationed would, no doubt, agree to keep them in repair and fit for sea on the principle which has prompted the Cape offer of £30,000 a year, and Natal's offer of coal. This disposes of the most dangerous part of the trade routes,—the points of arrival and departure.

My plans for the maintenance of the lines of communication in blue water are to have practically stationary vessels of good coal capacity and defensive action, serving as the centres of a line of patrol on each of the principal trade routes. Such vessels as the *Northumberland*,

Agincourt, *Achilles*, and *Minotaur* should be rearmed and kept ready for this particular service. It does not matter that they would be slow. Their armour and offensive force would be sufficient to cope with all probable adversaries, as these adversaries would, in the ordinary course of events, consist only of cruisers and auxiliary cruisers, if the battle-ship fleet did its work in blockading the enemy's battle-ship fleets.

These "pivot" ships would be accompanied by special colliers, ammunition ships, and repairing ships, so as to be self-supporting, and enabled to keep at sea as long as possible. There should be attached to them four or five smaller, but very speedy, cruisers, which should act as patrols and convoys, radiating on a curve of search from the pivot ship. Other cruisers should keep patrolling the line of communication between these centres and the nearest naval base, or chief port of departure and arrival of the mercantile marine. All vessels of the mercantile marine should be passed on from the cruisers at the neck of the bottle to the nearest centre, and from one centre on to another. This would, I believe, be the only effective system open to us at the commencement of hostilities. It would have the advantage of securing the safety of the trade routes by the fewest possible number of vessels, and of making it much more difficult for stray cruisers or privateers to prey upon our commerce undetected.

The advantages of wireless telegraphy, utilised in connection with this system, are very obvious. This leads to the consideration of another very serious aspect of the question, and this is the protection of cables and the communication between ships of the fleet and ships of the mercantile marine. There is no doubt that soon after the outbreak of war, a determined effort would be made to cut our cables, probably at a point where the deep sea cable joins the shore end. It is of the highest importance, not only to our navy, but to the commercial community, that this line of communication should be maintained intact. We ought to have properly equipped cable ships, ready to start as soon as war was declared, to pick up the cables at the point mentioned and to relay them to an unknown point.

All of the present cable routes are well known to all possible enemies, but the risks of destruction are greater about three miles from our coasts than anywhere else, and if we picked up the cables and relaid light ends, we should seriously disconcert the enemy.

The system of communicating between ships of the navy and ships of the mercantile marine is very bad. A great many vessels could be saved by speaking them and informing them of the outbreak of hostilities, and what to do; but the present code is very old, and apparently very little used. I can give only my own experience when returning to England in H. M. S. *Undaunted*. I signalled thirty-two vessels of the mercantile marine, but could get answers only from seven. It is imperative that ships of the mercantile marine should, in their own interests, be able to read and reply to signals promptly.

At present the fastest vessels of the mercantile marine are retained as auxiliary cruisers at the disposal of the government in time of war. In all cases of ships subsidised by government, only Royal Naval Reserve crews should be allowed to be carried. Some of the vessel's armament should also be carried, so that she could speedily be transformed for purposes of defence or attack. The crews should practice firing at intervals on their own ships. The *Teutonic*, which was fitted out with her guns on board to take part in the naval review, was not allowed any ammunition, so that, except for display, her fitting out was useless to her officers and crew.

Every encouragement should be given to British shipowners to build fast ships, and vessels engaged in the food supply of the country which could show a clean pair of heels to any pursuer would be invaluable in time of war. An idea which emanates from Canada is for the subsidy of a Canadian line of vessels of

great speed, specially built for the conveyance of food supplies.

The coal supply of the pivot ships engaged in protecting the trade route has been mentioned. The colliers referred to would have to be built. It is not sufficient for us to possess coaling stations to which vessels would be compelled to return very often. We ought also to possess a properly organised fleet of government colliers, ammunition ships, repairing ships and cable ships, to accompany fleets. The collier should be in direct communication with the coal mines or coaling base, and so save the expense of the present system. This would also save vessels being compelled to return to their coaling bases too often, a duty which could be performed by the colliers.

At present, the coal is shifted from the mine to train; from the train to a coal wharf; from the wharf to a lighter; and from the lighter to the ship. The steam collier should be the sole go-between, and should be properly fitted for coaling at sea. The present lighters are all of different lengths and different height of freeboard, and so the appliances for coaling can be only extemporary and inconvenient. Coal is most important, and the "life" of the patrol ships on trade routes, *i. e.*, their coal endurance without the necessity of returning to port, would be increased enormously by a system of proper steam colliers, meeting them at certain points. These colliers should have been built this year out of the unappropriated surplus of £800,000 of last year's balance on new construction. At the time of writing (May 25) the First Lord complains of not being able to make up more than £1,400,000 of the dangerous deficiencies in our ship-building programme, owing to a want of armour. Then why not spend the money on these useful and necessary auxiliaries, like steam colliers, which must be provided if our fleet is to do its duty of maintaining our commercial interests at sea?

These questions are very serious ones, and must be properly thought out before hostilities commence. Even if our trade is diverted to less exposed ports in time of war, we shall have to deal with the problem of its distribution. Half a million of London's population finds employment in the receiving, storing, and forwarding to all parts of food supplies. If these be interrupted, these people will be thrown out of employment unless their special knowledge and work is utilised elsewhere.

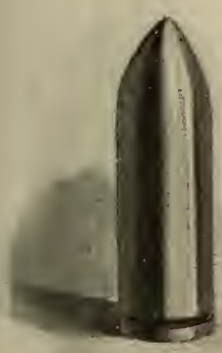
The war between the United States and Spain will not be an unmixed evil if it brings nearer home to us the moral of necessary organisation for the protection of commerce in time of war; and the war, and the various other causes which have sent up the price of wheat ought to teach us a lesson of which we are urgently in need. I have always held that if we go to war, and, through lack of foresight and organisation, bring about a stoppage of food and raw material, it is possible that the working classes will turn on the so-called governing classes, and will hold them responsible for their miseries.

A hungry British population would be very difficult to manage, and more so than those of foreign countries. Nor would it mend matters to call upon their patriotism in such a crisis. The growth of education would make a difference to the old order of things. Then, the men would buckle on cutlasses and go out to fight if there was any one to lead them. Now, it is more than possible that they would say, "You have brought us into this miserable condition, and now you ask us to go out and be shot."

A terrible responsibility rests on the men who are paid in time of peace to organise and prepare for the protection of the national interests in time of war, and a terrible retribution will be exacted from them by the nation if it is found that they have failed in their duty.

PROJECTILES FOR MODERN NAVAL ORDNANCE.

By Professor Phi'ip R. Alger, Bureau of Ordnance, U. S. N.



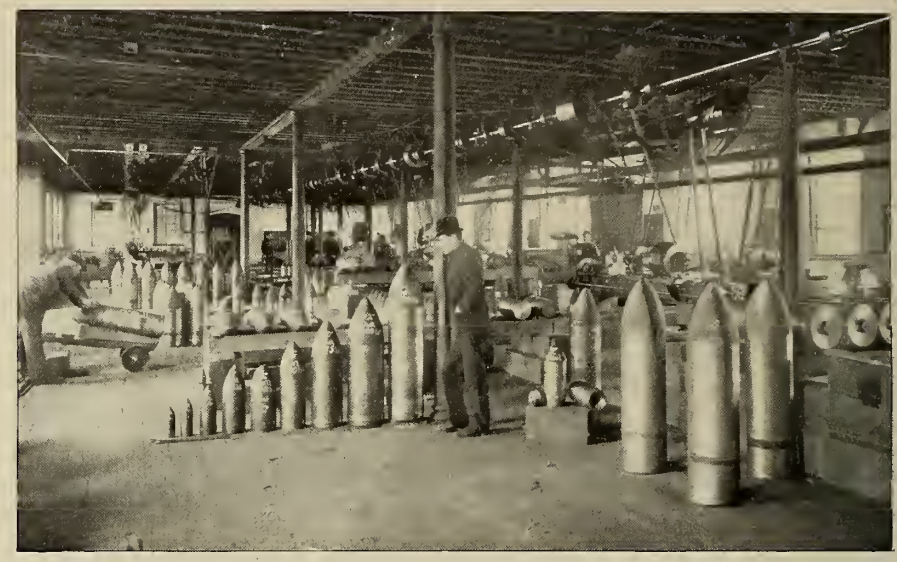
OF all the various forms of projectiles whose development has marked the progress of artillery, few remain in use at the present day, and the tendency is towards simplification rather than the reverse. Bar shot, chain shot and grape have disappeared from use, and, though canister and shrapnel still remain, the latter tends to take more and more the place of the former and to become the sole survivor of its class of projectiles. Solid shot, too, are going out of use, and the different kinds of explosive shell are gradually being differentiated into two classes, those to be used against armour and those to be used against unarmoured structures.

But before describing the projectiles used from modern guns, a few words may be said in regard to their general characteristics. With the old smooth-bore guns the different kinds of projectiles, all being spherical, necessarily had different weights, the shell weighing less than the shot and the shrapnel weighing more than either shot or shell; but with the modern elongated projectiles it is possible, and is the best practice, to make all the projectiles of each calibre of the same weight, and also with the same form of head, so that the same sight graduations may be used whatever the projectile.

The usual weight in pounds adopted for modern projectiles is one-half the cube of the calibre in inches, the 10 inch projectile, for example, weighing 500 pounds. The length is from three to four times the diameter, except in special cases, and the form of head is an ogive, with a radius of about two calibres. The diameter of body is usually from two to four hundredths of an inch less than that of the bore of the gun, the latter dimension being technically known as the calibre, both of the gun and of the projectile.

A number of different methods have been used for imparting rotation to elongated projectiles, but the modern one, in almost universal use, is by what is known as the compression system, which is only practicable with breech-loaders. This system consists of fitting around the body of the projectile a band of soft metal whose outside diameter is greater than the calibre, so that when the gun is fired and the projectile is forced through the bore, the bands of the rifling cut into the rotating band and the soft metal of the latter completely fills the grooves and prevents escape of gas past the projectile. At first wide bands of lead or copper were used, but in modern practice a narrow copper band fitted into a shallow score near the base of the projectile is universally employed.

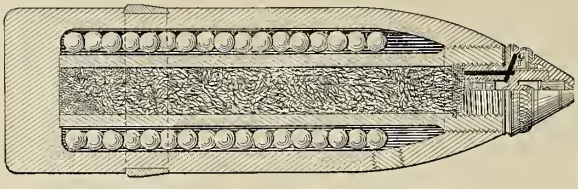
Experiments have shown that only slight differences in range are caused by varying the position of the band, and a distance of one and a half inches from the base has been generally adopted. It used to be customary to have a second, or steadying, band of soft metal around the larger projectiles at the juncture of ogive and body; but in modern practice this is dispensed with, and in its place the diameter of the projectile at the point referred to is made some-



THE PROJECTILE DEPARTMENT AT THE UNITED STATES ARSENAL AT WATERVLIET, NEW YORK.

what greater than elsewhere, the portion of increased diameter being known as the "swell" or the "bourrelet."

A few words also may be said in regard to the strains to which modern projectiles are subjected. That the force required to rotate them is comparatively trifling can be easily shown by mathematical analysis, and is practically illustrated by the fact that a soft copper band, less than two inches wide, forced into grooves only 0 05 in. deep, serves to rotate the 1100-pound projectile of a 13-inch rifle. The small percentage of the pressure on its base which is expended in rotating a projectile and in overcoming the friction of its band, can therefore be neglected practically, and it is only necessary in designing a hollow projectile to make the cross section of its walls at each point sufficient to bear the weight of that portion of the projectile which is forward of it, since each section is subjected, when the gun is fired, to a compressive force which just balances the force necessary to give the weight forward of it the acceleration which the projectile as a whole receives.



A 4-INCH SHRAPNEL, USED IN THE UNITED STATES NAVY.

If this be not done, the walls will bulge at the weak section; the body of the projectile will take the rifling of the gun; and it will either be broken up, or, at the least, will cause an excessive pressure in the gun. If, however, this one requirement be met, the projectile will be amply strong to withstand all other strains in the gun. It must be noted, however, that the strains due to the impact of the projectile are usually far greater than those put upon it by firing the gun, and a shell which can be safely fired with high velocity will break into fragments in passing through thin steel plating or even in entering a butt made of closely packed earth. Consequently, except in what are known as torpedo shell, the necessary strength for effective use will always insure an ample margin for safety in the gun. It is for this reason that modern shell are usually made

with solid, heavy points, and with walls that diminish in thickness towards the rear instead of the reverse, which would be preferable if strains in the gun were alone considered.

Such being the general characteristics of modern projectiles and the conditions which govern their design, there are still to be considered the conditions which have led to the development of the different classes and kinds of projectiles, and such a consideration will at once show that each kind of projectile has been devised to perform most efficiently a particular function.

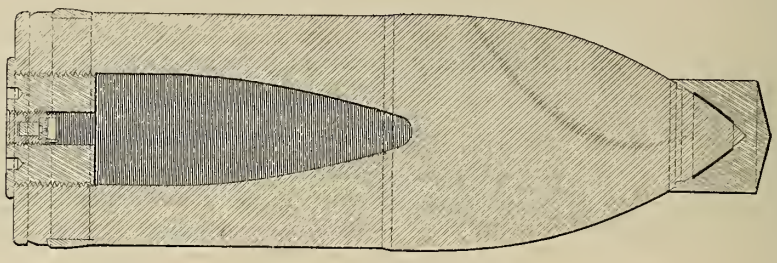
The function of projectiles is to destroy either men or material, and the class of projectiles of which canister and shrapnel are the modern representatives was developed for the former purpose exclusively. Gibbon mentions the use, at the defence of Constantinople, in 1453, of cases filled with scrap iron and fired from guns, and the modern canister differs from this only in being a case filled with iron or lead balls instead of scrap iron. Such projectiles, however, are ineffective at long range. They are broken up into their component parts in the gun by the shock of firing, and these parts separate more and more widely after leaving the muzzle, besides rapidly losing their velocity.

The shrapnel, which owed its perfected form to the British general after whom it was named, was devised to overcome this difficulty, and it is because the increasing destructiveness of modern weapons results in greater and greater fighting distances that the shrapnel more and more tends to take the place of the canister. The modern shrapnel consists of a steel case, strong enough to stand the shock of being fired from a gun, and containing a large number of small lead or iron balls and also a small bursting charge of powder, just sufficient by its explosion to break open the case and scatter the balls. The powder charge is usually placed in a chamber at the rear ends of the shrapnel, connected by a tube with the fuse, which is screwed into the point; but the

COMMON SHELL.

powder chamber may be at the point, or in the centre, without affecting the action.

What are known as time fuses are used in shrapnel for the purpose of igniting their bursting charges at the proper moment. These fuses are cut, or otherwise adjusted, to act at a range about 100 yards short of the objects aimed at, so as to give some dispersion and the powder charge fills the central chamber. The fuse is ignited by the shock of discharge from the gun, which causes a small plunger to shear its retaining pin and explode a cap which sets fire to a time train at such a point that it will set fire to the powder charge of the shrapnel after burning the prearranged number of seconds Another plunger and cap will cause the shrapnel

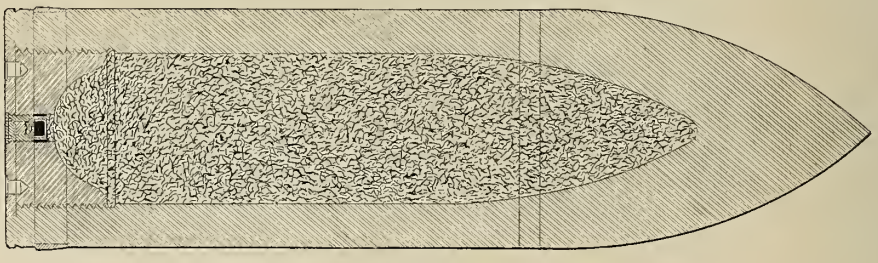


A 10-INCH CAPPED ARMOUR-PIERCING SHELL. WEIGHT, 500 LBS

to the balls and fragments before they reach the mark. Of course, by setting the time fuse at the zero mark the shrapnel may be caused to burst at the muzzle and thus perform the same function as canister.

Percussion fuses are found to give fairly good results with shrapnel used on land, the guns being so pointed as to cause the shrapnel to strike the ground short of the objects aimed at; to explode on striking in case the time fuse has failed to function. This 4-inch shrapnel contains 240 balls, and the steel case and cast iron tube are broken up by the explosion, adding a large number of fragments, all of which sweep forward from the point of explosion in a cone of increasing dispersion.

It is clear that such projectiles as those just described can have but a limited field of action in naval warfare,



A 13-INCH FORGED STEEL COMMON SHELL. WEIGHT, 1,100 LBS.

but for use at sea time fuses are evidently essential to the proper action of shrapnel.

The illustration on page 444 shows the shrapnel used in the 4-inch guns in the United States naval service. The balls are bedded in a matrix of rosin, since they are efficient only against exposed bodies of men. In firing at forts or men on shore they are very useful, but in an engagement between ships they would ordinarily play no part. Here is the sphere of action of the explosive shell, and it is this projectile

which, above all others, gives destructive power to modern naval ordnance.

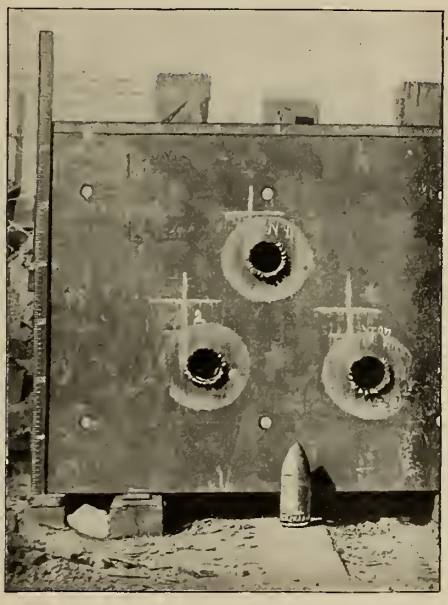
The earliest form of explosive shell, consisting of two hollow hemispheres, joined by a hinge and filled with powder, had been tried in the fifteenth century; but even in their more developed form of hollow balls made of one piece, shell were used only in high-angle fire, and it was not until after the appearance of General Paixhaus' celebrated work, "La Nouvelle Arme," in 1821, that shell came into general use for horizontal fire. The distinction of having devised and introduced the naval shell system is everywhere admitted to belong to Paixhaus, who advocated the use of explosive shell instead of solid shot so convincingly that the almost immediate introduction of shell guns into common use followed the publication of his book.

The weak point of the shell, as used from smooth-bore guns, however, was the difficulty of making them explode at the proper moment, and it was not until the use of the rifle principle, whereby elongated projectiles are projected point first, rendered it possible to cause shell to explode with certainty on striking, that their full destructive power became possible of realisation.

But in warfare the defence has always progressed *pari passu* with the offence, and the destruction effected by explosive shell soon brought about the use of armour to keep them outside and thus render them harmless. Undoubtedly the greatest destruction of men and of material will be produced by the shell carrying the largest bursting charge, provided only the said shell can reach them; but from the moment that the men and material are protected by a resisting structure the problem is changed and we have to consider not only the best method of producing great destructive effect after reaching the mark, but how to get there.

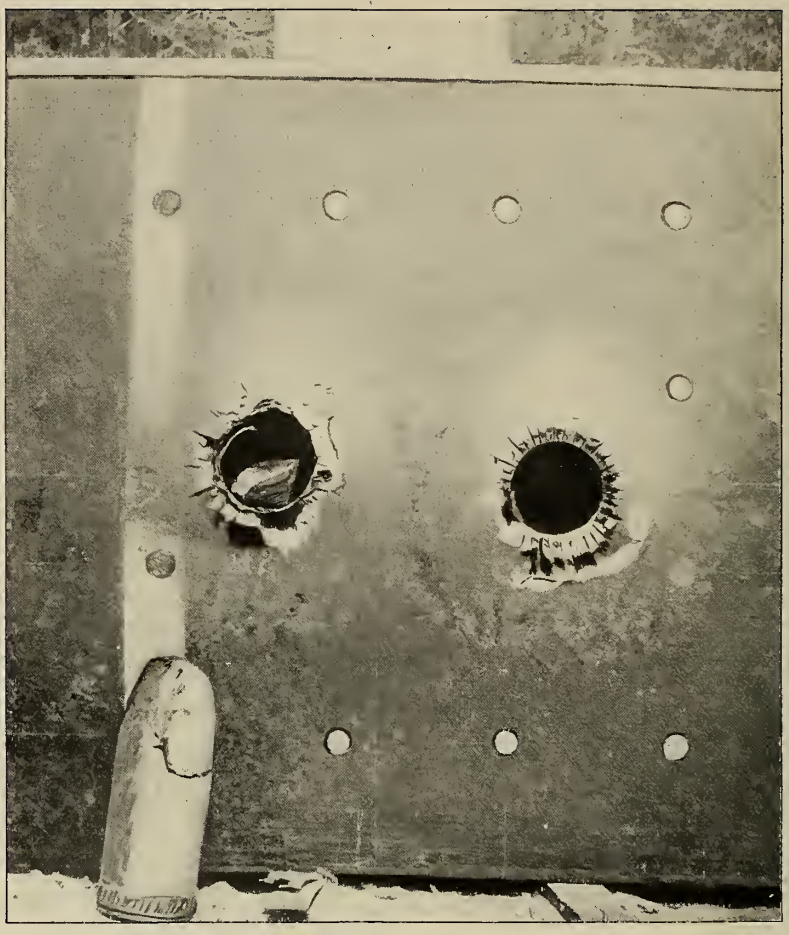
If we make our shell with very thin walls so as to carry a very large bursting charge, then instead of going through the side of an opposing ship and there bursting with murderous effect, killing and wounding men, and setting fire to and destroying material, it will break up and explode harmlessly on the outside. Until armour was used this difficulty did not exist—the thinnest walled shell that could be fired safely from a modern rifled gun will go through the side of an unarmoured ship and burst inside her; but with the extended use of armour, and especially with modern ships having a large area defended by comparatively thin armour, it has become most important, even at the expense of a considerable reduction in explosive effect, to make all shell strong enough to go unbroken through a reasonable thickness of steel.

Explosive shell, not specially adapted



A 6-INCH ARMOUR-PIERCING SHELL AFTER GOING THROUGH SEVEN INCHES OF NICKEL STEEL.

for use against armour, are known as "common" shell. They are made of cast iron, cast steel, or forged steel, but the latter is greatly to be preferred. Cast iron shell have been largely abandoned on account of their lack of strength, but cast steel shell, with thin walls and large bursting charges, are used in large numbers, especially in European naval services. Such shell are, of course, very effective against unarmoured structures, and also against



A 12-INCH SHELL AFTER HAVING BEEN FIRED THROUGH A 17-INCH HARVEYISED PLATE.

fortifications; but the fact that they are completely ineffective against even quite thin armour has led the United States Navy to prefer forged steel common shell, which, though they have less mine power, can be counted upon to perforate armour at least half their calibre in thickness.

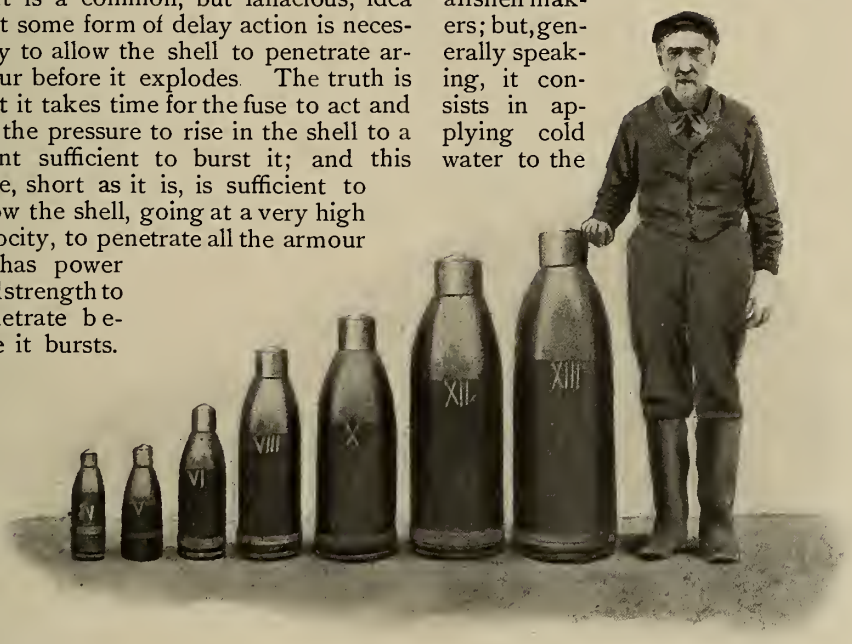
The illustration on page 446 shows the United States Navy forged steel common shell for the 13-inch rifle. It weighs 1100 pounds, carries a bursting charge of about 50 pounds of powder, and will go through six or seven inches of armour and burst on the inside,— a performance surely much to be preferred to that of a shell of equal weight, but carrying, say, 100 pounds of powder, which would burst harmlessly on the outside of similar armour.

It was formerly the custom to place the powder charges of shell in bags, called burster bags, with the object of preventing premature explosions from the friction of the powder against the walls of the shell cavity; but these bags are no longer used in the United States naval service, it being deemed a sufficient precaution to line the cavity with a smooth coating of lacquer whenever it is not already smooth from the method of manufacture.

The fuse shown is a simple form of base percussion fuse, and is the one

adopted in all United States Navy shell, excepting those of the small rapid-fire guns,—1, 3 and 6-pounders,—which employ a similar, but smaller, fuse. The shock of the discharge of the gun causes the plunger to shear its supporting wire, and when the shell strikes, the plunger flies forward and explodes the cap, which ignites the powder charge in the forward end of the fuse. This, in turn, sets fire to the bursting charge of the shell and explodes it.

It is a common, but fallacious, idea that some form of delay action is necessary to allow the shell to penetrate armour before it explodes. The truth is that it takes time for the fuse to act and for the pressure to rise in the shell to a point sufficient to burst it; and this time, short as it is, is sufficient to allow the shell, going at a very high velocity, to penetrate all the armour it has power and strength to penetrate before it bursts.



CAPPED ARMOUR-PIERCING SHELL.

In the early stages of the development of armour it was necessary only to somewhat thicken the walls of the cast iron shell and to chill their heads to render them fairly effective against armoured structures; but the advent of steel armour was soon followed by the introduction of the present type of "armour-piercing shell" of forged steel and highly tempered. It was found necessary, in order to obtain the desired combination of hardness and toughness, to use an alloy of chromium and steel, and consequently all modern armour-piercing shell contain, in addition to about one per cent. of carbon, a percentage of chromium ranging from 1.8 to 3.0 per cent. Crucible steel is used for making these shell, not only on account of its supposed superior quality, but because the proper admixture of chromium is difficult with the open-hearth method of making steel.

The tempering process, by which armour-piercing shell are rendered capable of penetrating thick steel armour without deformation, is kept secret by all shell makers; but, generally speaking, it consists in applying cold water to the properly heated projectile over a certain length from the point, both inside and out, while the remainder of the projectile is protected from the chilling effect, the result being extreme hardness from the point to, or somewhat below, the bourrelet, with gradually less hardness and more ductility from there to the base.

The illustration on page 447 shows a 6-inch armour-piercing shell which has passed unbroken through a 7-inch nickel steel armour plate and nearly four feet of oak timber. Although made hollow, these shell do not, as a rule, carry burst-

ing charges, the cavity being bored to enable them to be more thoroughly hardened without danger of cracking from the tempering strains. Indeed, such shell cannot be burst by a charge of ordinary powder, and when it is desired to make them explosive they must be loaded with some high explosive, more powerful than gunpowder. Their greatly increased destructiveness, if caused to explode after passing through armour instead of remaining whole, has recently led to the adoption of bursting charges of either guncotton or some other high explosive, such as joveite or

TWELVE-INCH ARMOUR-PIERCING SHELL AFTER GOING THROUGH 12-INCH STEEL ARMOUR PLATE.

picric acid, which, while sufficiently stable to be fired safely, can still be exploded by the action of an ordinary fuse.

In this case the explosive is not detonated, but is simply ignited by flame from the fuse, its rapid combustion in the closed chamber causing sufficient pressure to burst the shell, and the development of the pressure being sufficiently slow to permit the shell to pass through the armour against which it is fired before the explosion takes place.

Although armour-piercing shell had been developed to such a point that they could be fired uninjured through a thickness of iron or soft steel limited only by the striking velocity, yet these same projectiles proved quite incapable of withstanding the strains of impact against modern hard-faced armour. In the former case the shell remained whole and practically undistorted, and consequently it performed its function perfectly, delivering the whole energy of the gun in the form of useful work on the armour plate.

The successful introduction of the process of surface-hardening steel armour plates, however, changed this completely. The projectile broke into fragments upon impact with such plates, and a very large percentage of its energy was dissipated in useless work upon itself. On page 448 is shown a 12-inch armour-piercing shell which was fired through one of the earlier hard-faced plates. The plate, which was 17 inches thick, was not a very good one, and the shell, which had a striking energy of 20,364 foot-tons, was an exceptionally good one; yet the picture shows how its point has been crushed by the hard surface of the plate.

It has been discovered, however, that a simple means of overcoming this difficulty, to a considerable extent at least, exists. The fact that the old compound armour plates, which were an imperfect form of the modern Harveyised armour, could be readily perforated if attacked on the soft side, led to the trial of shell fitted with soft metal caps, and the analogy proved a correct one. It was found that capped shell could be fired whole through plates upon whose surface similar shell, but without caps, broke into fragments.

The upper illustration on page 446 shows an armour-piercing shell, capped, used in the 10-inch navy rifle. Such a shell, loaded with joveite, has been fired through a 14-inch Harveyised plate and burst on the further side. A picture of this plate is shown on page 451 with an unloaded, but capped 10-inch armour-piercing shell that had previously been fired through it, and the action of the cap in protecting the point of the shell is apparent. It is possible that future

A 10-INCH CAPPED ARMOUR-PIERCING SHELL, FIRED THROUGH A 14-INCH HARVEYISED PLATE.

improvements in manufacture may enable us to dispense with caps, but for the present at least they greatly increase the efficiency of armour-piercing projectiles, and as the caps have no appreciable effect on range or accuracy, they are being fitted to all such projectiles in the United States service.

These, then, are the projectiles fired from modern naval guns,—the shrapnel, used against exposed men; the common shell, carrying a considerable powder charge, but with something of its possible mine power sacrificed to increase its power of penetration; and the armour-piercing shell, capped to increase its efficiency against hard-faced armour, and carrying a sufficient explosive charge to break it into a number of fragments after it has passed through.

But there remains to be considered the "high-explosive shell," which, many people think, will revolutionise naval warfare when the great inventor appears who is to reveal the secret of how to fire it safely. There is so much misconception on this subject that it seems worth while to consider it at some length. In the first place, it must be clearly understood that what are known as "high-explosive shell" are not used in modern naval ordnance, not because they cannot be safely used, but because the disadvantages attending their safe use are thought to more than counterbalance their advantages.

The danger in firing any explosive from a gun lies, of course, in the possibility of its going off in the gun and bursting the latter, and it is merely because the detonation of a high-explosive shell in the bore will certainly burst a gun, while the explosion of a powder shell will probably not, that the firing of the high-explosive shell is considered specially dangerous.

Whatever the character of the gun, the explosive must be contained in some sort of a projectile, and that projectile must be given velocity by some sort of an accelerating force, whether the expansive force of compressed air or of powder gases, and the acceleration of the projectile at each instant must be a true measure of the force acting on it and on its contents. When the driving pressure on the base of the projectile is greatest then is the acceleration the greatest, and then is the shock tending to explode it greatest. Nothing is

gained by applying a small pressure at first and gradually increasing it; the maximum pressure on the base of the projectile, whether it occurs before the projectile has had time to move or just as it reaches the muzzle of the gun, is what measures the danger of an explosion. Consequently, whatever form of gun is used for firing high-explosive shell, the one requirement for safety is that the maximum pressure on the base of the projectile shall not be too great.

It is just as safe to fire any high-explosive shell from a powder gun as from an air gun, provided we limit the powder pressure to the pressure used in the air gun. A projectile fired from a powder gun has not time to be heated by the powder gases, and leaves the muzzle at practically the same temperature as when loaded into the gun. Neither does the rapid rotation, caused by the rifling, produce dangerous friction of the explosive against the walls of a projectile. The real danger is from the setback of the column of explosive caused by the forward acceleration of the projectile, and so long as we keep this within safe limits it matters not how we produce it.

But the high explosives, and especially the detonating materials necessary to develop their full force, are much more sensitive than is gunpowder, and, therefore, if we desire to use high-explosive shell instead of powder shell in guns, we must reduce the propelling charges so as to keep the pressures within the limit of safety, and we must accept the resulting disadvantages of lower velocities, higher trajectories, and lessened chances of hitting.

How much we must reduce pressures and velocities depends, of course, upon the quantity of explosive which we wish to throw, since, the column of explosive being driven forward with accelerated velocity, the greater the height of that column, the greater the pressure on its base, and consequently the greater the danger of explosion. If the present common shell were loaded with guncotton instead of powder it would be necessary to only slightly lessen their present velocities; but if we wish to fire very large charges of high explosive, we can attain a reasonable degree of safety only by greatly reducing the powder pressures and by being satisfied with comparatively low velocities.

The question is, then, how great is the gain from using a high-explosive charge for shell instead of an ordinary powder charge, and it is on this point that popular opinion errs. The effect of high-explosives is enormously exaggerated not only in the popular mind, but almost universally. The idea that such public buildings as the Capitol at Washington, or the Houses of Parliament at London, can be destroyed by the explosive carried on the person of an anarchist can hardly gain the credence of an intelligent man, though such is the apparent belief of many newspaper writers. But the equally unfounded idea that a battleship can be destroyed by a high-explosive shell meets with common acceptance. The fact is, that while high explosives produce very great effects upon material in close contact with them, these effects are comparatively local.

Experiments made at the United States Naval Proving Ground at Indian Head, Md., have shown that while a high-explosive charge will burst a common shell into more pieces, the general effect on the surroundings is, on the whole, rather less than when they are burst by ordinary powder charges. The greater force of the high-explosive seems to waste itself in tearing and shattering the shell itself. Moreover, the powder charge sets fire to anything inflammable in the neighbourhood of the explosion, while the high-explosive does not.

Clearly, then, there is no present reason for using anything but powder as the bursting charge of the common shell, and the field for the high-explosive, if there be a field for it in naval warfare, is in what have been called torpedo-shell,—shell with thin walls and of great length, so as to carry very large charges. But all the experiments thus

far made have indicated that here, too, the results to be obtained have been grossly exaggerated. Even the largest of such shell, containing three or four hundred pounds of guncotton, exploded against the armoured side of a modern battle-ship, would be practically harmless, and exploded in the air near such a ship would cause no serious structural damage.

If such shell could be fired through the side of a vessel and burst inside her, they would, of course, produce widespread destruction and be much more efficient than common shell of equal weight; but from their very nature this is impossible. They must be very weak in order to have great capacity, and they are quite certain to explode outside of any ship that they may strike.

There is, then, comparatively little to be gained in destructive effect by the use of "high-explosive shell," while we would lose what is of the utmost importance at sea, the flatness of trajectory which makes it possible to hit even when the distance of the target is only approximately known. The writer, consequently, has been forced to the conclusion that the advantages of using high-explosives in shell are outweighed by the disadvantages, and unless some new light is thrown on the subject in the future we should continue to use as projectiles for naval ordnance only those now used, and which it has been the object of this article to describe.

Current Topics.

For the difference between building machinery and manufacturing it, probably few better illustrations can be found than those afforded by the steam engine industries of Europe and the United States. American steam engines, and water-wheels, too, are turned out in quantity, like shelf hardware, and can be bought at almost a moment's notice, much as one would buy barrels of flour, with a large range of sizes available for choice, while the preponderating rule in Great Britain and on the Continent is to build them to order and after special designs, so that there is a marked absence of uniformity of product. One reason for this variety of designs, which we do not remember having ever seen stated before, is that for British mills and factories, for example, often of venerable age, new engines, when required, must be built to fit in particular places,

—places previously occupied by engines of earlier, and, mayhap, historic make,—and curious shapes and combinations are, therefore, made compulsory to the builder of the new outfit. Out of twenty mill engines, for example, recently ordered in the Lancashire district, only two, it was stated, were intended for new mill buildings; all the others were to replace engines of past generations, and had to be fitted into the old quarters of these. That with such conditions there cannot well be an underlying standard of design is obvious, and odd features of construction will, doubtless, therefore continue indefinitely. In the United States the factory, one might almost say, is built with special reference to the engines kept in stock. Designs of extraordinary character are not often needed, nor are they wanted, and with a study of a comparatively few types one is fairly familiar with the current steam engine practice of the country.

For years the whole world has been wondering what the teachings would be of the first great battle between modern ships of war. Now that that battle has been fought and the town of Santiago, in Cuba, has, through it, acquired new historical fame, the vital part played by speed in the vessels which were engaged in the recent drama there stands out in bold relief. The United States ships had armour and ordnance of overwhelming strength, and, yet, relatively few of them were able to overhaul the swift *Colon*, of the Spanish fleet. Indeed, if Admiral Cervera had chosen to come out at night and scatter his vessels on various courses, instead of proceeding in line ahead, his ships might not to-day lie shattered on the Cuban coast. To win success in that case, the few swift United States ships would each have had to select, in darkness and surprise, its especial antagonist, and, instead of one column, on which all of the fire was concentrated, there would have been at least four, on widely divergent lines, with, perhaps, on one or more of these, only one of the slower, if in other respects more formidable, American ships in chase. The whole story of the action might, in this way, have been changed. As it was, the margin for the victors was narrow enough, and the United States have all reason to congratulate themselves that they had on hand at least one battleship,—the *Oregon*,—in which high speed in service trim was not a myth.

Several years ago Laird Clowes, one of the ablest British naval authorities, defined the requirements of the ideal fighting ship to be, in his opinion, great speed, moderately thick armour, and numerous quick-firing guns, and all the experience of the intervening period, with the Santiago battle as the feature of overshadowing import, seems to have demonstrated almost beyond question that he was right. As to armour, for example, three of the Spanish ships at Santiago had armour-belts only along the water-line. With their guns uninjured and their engines intact, they were run ashore, in each case a mass of flames. Through the unarmoured sides shells had penetrated, setting fire to every inflammable part. The fourth cruiser, the *Colon*, steamed for fifty miles through the same flood of projectiles, was never, as far as is known, on fire, and was beached practically uninjured. Her immunity from the flames seems to have been due to the fact that, while her armour was of about the same weight as that of the other cruisers, it was disposed in a sheet, covering the hull almost entirely, and giving her needed protection above the water line. There seems to be, in this, abundant support for the belief of many naval experts, besides Laird Clowes, who would have 6-inch armour all over his ship, that it is better to cover large areas with thin armour than small areas with a narrow belt.

When we come to the gun question, it is worth recalling that in Clowes's

ideal ship,—the ship, as he called it, against which no man-of-war in existence could stand up, and from which no man-of-war in existence could escape,—there were to be 101 guns, none of them above 6-inch calibre,—in fact, only sixteen of that weight,—and all of them quick-firers. It is all the more interesting to note, therefore, that the hits by ordnance of large calibre were so few at Santiago as to make its part in this action insignificant as compared with the work of guns of medium and small bore. The fire, merciless in its energy, accuracy, and destructiveness, which the lighter American guns poured out like a flood, has certainly helped in great measure to strengthen belief in the advisability of arming ships to as great an extent as is possible with rapid-fire ordnance of all calibres. Thus the lessons of perhaps the only battle thus far between thoroughly modern ships of war have closely followed the lines laid down by expert opinion years before.

Apropos of non-inflammable wood, one variety of which is now being very strongly advocated for use in United States naval vessels, it would seem pertinent to add to what was recently said on the subject in these pages, that, according to official reports of such trials as have been made with the material on American warships, the wood was liable to dampness and rot, and the decks consisting of it wore down, showing that it was soft and had no life. It was believed also that it was friable and would splinter badly when under fire, and this last-mentioned defect, if existent, would alone constitute a very serious drawback to its use. It would, indeed, emphasise the desirability, not of fire-proofed wood, but of no wood at all. What would appear to be more preferable in many respects is asbestos, or some similar material, either as cardboard for lining metal surfaces, or built up in a grooved or cellular form for bulkheads. Such material would, of course, be absolutely uninflammable, and a shot through it would make a clean hole, with no splinters whatever.

With the later report that all wood to be used in the new vessels of the United States Navy will be fire-proofed, comes also a daily newspaper interview with Chief Constructor Philip Hichborn, U. S. N.,—the only one, by the way, of the four members of the United States Board of Naval Construction who advocates the use of such fire-proofed wood,—according to which he says that the process to be followed of rendering wood non-inflammable, "simply stated, consists in withdrawing all sap and moisture from the lumber in a vacuum and then filling the pores with phosphate of ammonium." But this is substantially the Pepper process, doubtless with valuable improvements in detail, while adhering to the phosphate of ammonium, which was found, on the whole, to give the best results in making wood non-inflammable. This particular virtue of phosphate of ammonium has been known for years to chemists, yet the British, French and German navies have been able to make little or no use of it, though all three have spent considerable amounts of money in trying to discover an efficient non-inflammable wood for their warships. It might be urged that its practical rejection hitherto for warships was due altogether to the fact that these navies wanted a non-splintering, as well as a non-inflammable, wood. But this contention falls to the ground when it is remembered that the British mercantile marine, which need have no fear of wood splinters from shell fire, has been equally ardent in its search for a satisfactory non-inflammable wood, without, apparently, finding it. Moreover, so far as is known, all the salts of ammonium are soluble in water,—most of them extremely so,—and if phosphate of ammonium is an exception to the rule, Roscoe forgets to mention it. Nothing could be more calculated to set the minds of naval officers and men at ease

during a battle than the consciousness that, happen what might, their ship could not take fire; but nothing could be more expressly planned to start a panic among men engaged in action than the sudden discovery that the so-called non-inflammable wood was on fire owing to its chemical constituents having become leached out by washings and evaporation.

It was America's great showman, the late P. T. Barnum, who made the statement that the public like to be humbugged. Certainly there has been ample evidence in the world's history in support of his view. There have been perpetual motion machines galore, magnetic motors, Keely motors, and a multitude of other apparatus for the extraction of money from the pockets of gullible investors, and with all the discomforting experiences of these, they still bob up serenely, ready to put more money into almost any worthless enterprise that may come along. It is only a few months ago, for example, that a "gold from sea water" scheme was started in the United States, and now comes the news that the whole thing has collapsed, and that the "inventor" of the process and manager of the company,—the Electrolytic Marine Salts Company, of North Lubec, Me.,—has absconded after having received the snug sum of $338,000, or about £67,600, of the "profits," which were derived not from sea water, but from the stockholders. According to a recent news paragraph he sailed for Europe under an assumed name after having converted about $100,000 cash into government bonds in New York City. It is said that about $300,000 out of the $10,000,000 capital stock of the company were put in by bank directors and leading business men of Newburyport, Mass., who were led to subscribe through their confidence in the judgment of a local capitalist and a large shoe manufacturer of that city, both of whom were directors in the company. One report says that $2,400,000 of the stock has been sold at par, that 45 per cent. of the money received went to the promoters, 20 per cent. to the "financial agents," and the remaining 35 per cent. into working capital, some of which was expended in the construction of the works at North Lubec, upon which 600 men have been engaged.

The New York *Herald* a month ago gave an interesting account of the preliminary experiments of the "inventor," near Providence, R. I., by which he obtained his first contributions of capital. It appears that a small shed was built at the extremity of a long, slender wharf projecting from the shore of Narragansett Bay, and through a hole in the floor there was lowered, by means of a windlass, a large box containing a pan of mercury. An electric battery supplied by the "inventor" was applied during a whole night in the presence of some capitalists from Middletown, Conn., who had brought with them the mercury. The next morning the mercury was lifted from the water and given to a chemist, who assayed it, and found in it $4.50 of gold, and thereupon the capitalists, much pleased, paid the first installment on their investment. The deception in the experiment, according to the detective, consisted in a diver's proceeding under water during the night to the box, pouring out the mercury, and substituting for it another lot of mercury containing gold. Upon this basis was floated the $10,000,000 company. Its success in obtaining gold at North Lubec was attested by its sending frequently to the New York Assay Office "gold bricks" containing each about $2000 of gold, and the exhibition of similar bricks at the company's office in Boston. The "gold from sea water" scheme thus appears to have been one of the most gigantic swindles of recent years. It was similar in many respects to the Electric Sugar Refining swindle in New York City in 1884, by which many prominent business men, including even sugar refiners, were victimised.

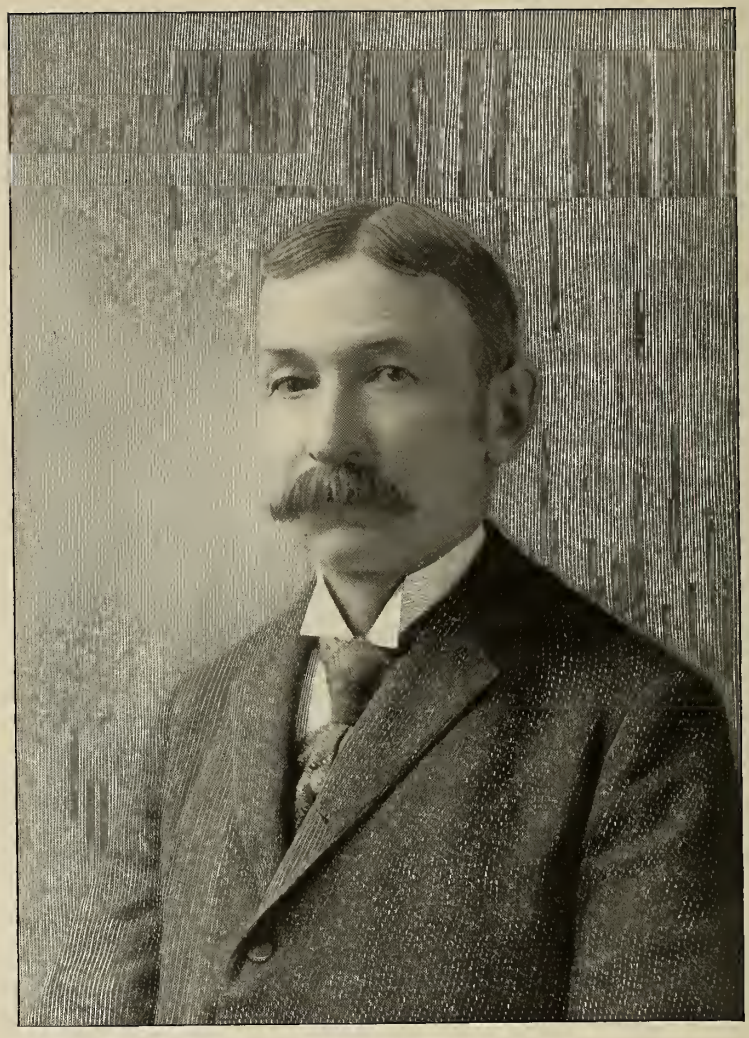


PHOTO BY ANDERSON SPRINGFIELD, ILL.

THE LATE ALBERT L. IDE.

(See page 544.)

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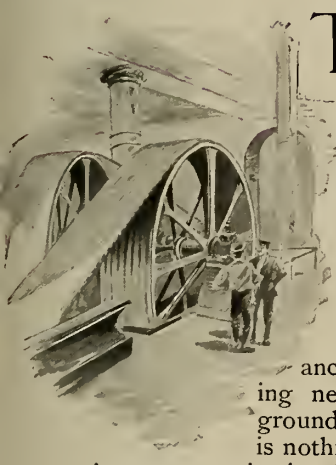
THE GLASGOW DISTRICT SUBWAY.

THE WORLD'S FIRST UNDERGROUND CABLE TRAMWAY.

By Benjamin Taylor, F. R. G. S.



THE Glasgow District Subway is in many respects one of the most remarkable systems of vehicular traffic in the world. Yet it embodies no novelty in principle, or in mechanical appliance. There is nothing new in an underground railway; there is nothing new in cross-river communication by means of tunnels; there is nothing new in the running of light cars with mechanical traction for intramural transit; and there is nothing new in the cable as a method of traction on tramways. The novelty in the case of the Glasgow District Subway is in the combination of several features never before found together.

Although regulated by the Board of Trade as a railway, it is simply an underground system of cable tramways. It is all underground, save at a few of the stations, and it is worked entirely by cables driven from one power station. It is a tubular railway in two circles, the cars running in opposite directions through two separate but parallel tunnels. Thus, two ropes are required, one for each tunnel, on the inner track and outer track, respectively. The whole distance around the circle is 6½ miles, and for each circle about seven miles of wire cable are wound on to the pay-out drums.

The route is within the most populous and most actively employed areas of the city, and in the completion of the circle the river Clyde has to be dived under twice. As a system of street traffic the line traverses at several points three other systems of city and suburban lines of communication, with which it comes more or less into competition, viz., the street tramways system of the Corporation of Glasgow and the circular underground railways of the North British and Caledonian Railway companies. Yet it serves portions of the city not served by either of these systems, and it affords a valuable connecting link between these other systems. While, like Hal o' the Wynd, fighting for its "ain hand," the Glasgow District Subway also acts as a feeder to its competitors.

One distinct advantage of the subway is that it relieves the congestion of the street traffic without rendering the

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PHOTO BY MACLURE, MACDONALD & CO., GLASGOW.

A VIEW IN THE TUNNEL.

streets unsightly, as an elevated railway does; and another advantage is, that while it conveys passengers under the streets, it does not stifle them with sulphurous fumes, as an underground steam railway does. Still a further advantage is, that by running in separate tunnels, with fixed stations, the subway can convey its passengers at a speed twice as great as that possible with cars of street tramways, even when these have mechanical traction.

The design of the Glasgow Subway is about a dozen years old, although the system has been open for traffic only since the beginning of 1897. The credit of the inception of the scheme belongs to Mr. Alexander Simpson, C. E., of Glasgow, whose firm, Messrs. Simpson & Wilson, have been throughout, and still are, the engineers of the enterprise. Naturally, as in all great works, there has been much departure from the original design. Mr. Simpson's first idea was for an underground cable railway, of something under three miles, between the centre of Glasgow and the adjoining burgh of Partick,—in one tunnel only, with two sets of rails. On this plan the stations were to be equidistant, and the cars, attached to an endless chain, were to start and stop simultaneously. The engineman at the power station would alone have control over the two sets of trains, and would let out the requisite length of rope when he received signals from all the stations.

This idea was ingenious (though one can now see many objections to it), and it received the approval of the House of Lords; but the bill was thrown out by the House of Commons, in 1887. Next year the scheme took a larger form and another shape, appearing in a plan for a double line in two tunnels to connect the north and south sides of the river, as well as the districts of the previous proposal.

The Clyde Trust opposed this scheme as both invading their domain and as calculated to prevent, or obstruct, the

future deepening of the river. Their opposition was successful, and the subway design was suspended until another undertaking was carried through Parliament, viz., one for a tunnel under the Clyde for pedestrian traffic. After this had established a sort of right-of-way precedent, the subway scheme was again sent up to Parliament, and in 1890 it was sanctioned, in spite of the opposition of the Caledonian Railway Company, then busy with the construction of their city and suburban underground line.

The subway line was completed in 1896 and opened for traffic in January, 1897. Under the act the Glasgow District Subway Company acquired the right, or free way-leave, to pass under, and follow, the lines of streets. But with a much larger capital than was necessary for the actual construction and equipment of the subway.

As an underground railway the subway is not remarkably deep. It is true that at one place, Hillhead, the distance from the street surface to the top of the tunnels is 115 feet, but that is because the line at that point passes under a considerable mound. At another place the depth is only 7 feet, and at one point in the centre of the city the depth is 40 feet. Averages in such circumstances do not mean much, but the average depth for the whole length of the tunnels is 29 feet from the street surface.

The tunnels are practically two endless cylindrical tubes, at slightly varying distances apart, but opening out

PHOTO BY MACLURE, MACDONALD & CO.

ONE OF THE CARS.

the circular design necessitated the passing under much private property, the owners of which were, or professed to be, alarmed at the prospective effect of the tunneling on their buildings. The company, therefore, had to purchase large blocks of property, which may, and undoubtedly will, ultimately yield a good return as an investment, but which have weighted the undertaking together at each station into one large arch of 28 feet span. At suitable intervals along the tunnels are openings through which the surfacemen may pass from one line to the other without returning to a station. The general curvature is very considerable, yet the sharpest curve on the line is of not more than 660 feet radius. The gradients, while easy for cable traction, would be

ONE OF THE STATION PLATFORMS, SHOWING THE CABLE AT A CURVE.

PHOTO BY MACLURE, MACDONALD & CO.

regarded steep for steam or electric power,—those where the tunnels pass under the Clyde being 1 in 18 and 1 in 20, respectively.

The tunnels were formed for the most part on what is called the "cut and cover" method. Where brick-clay was encountered, ordinary brick tunneling was used. In passing under important blocks of buildings and factories, the work was done by iron tunneling, sometimes with, and sometimes without, the use of compressed air. In working beneath the river the tunnels were driven under air-pressure, with such effect that the river bed was blown up about a dozen times before the crossing was completed. The cross-river tunnels are remarkable triumphs of constructive engineering under extremely difficult conditions. It is a noteworthy fact that the cross-river portions are the driest parts of the whole tunnels,—and the subway is carried once under the River Kelvin, as well as twice under the Clyde.

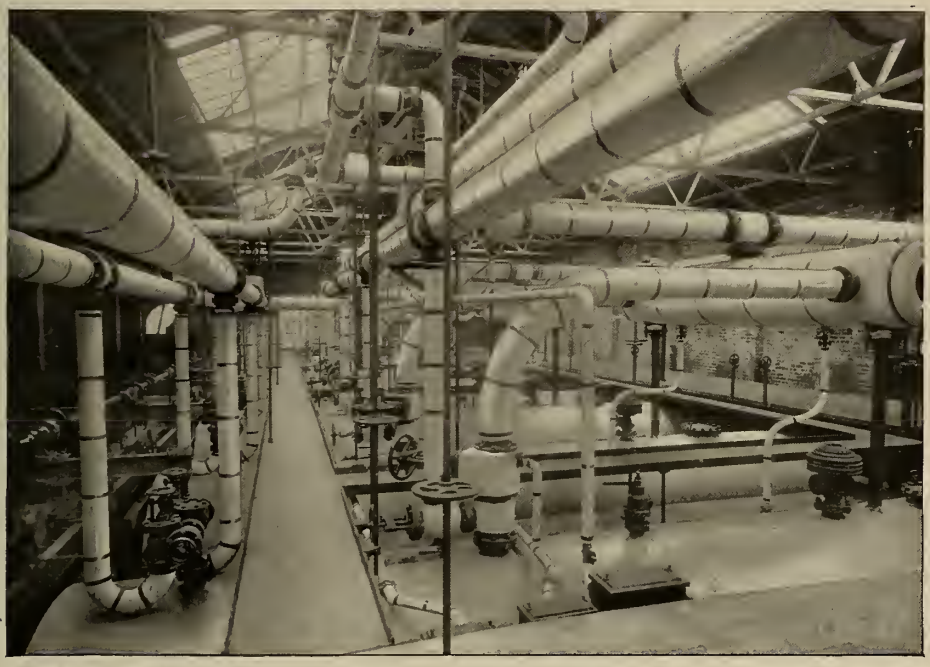


PHOTO BY MACLURE, MACDONALD & CO.

A VIEW IN THE BOILER HOUSE.

A drainage system had to be constructed to carry off the water that must accumulate in all underground workings. For the section between Partick and Cowcaddens, which one may call the northwestern segment of the circle, a brick conduit was constructed, of 4 feet diameter, to run the drainage into the River Kelvin. On the section between Cowcaddens and Buchanan street, there is gravitation drainage into this conduit. On the eastern side of Buchanan street station there is a fall to St. Enoch station, where the water is pumped into the sewers.

On the south side of the river there is no natural outfall, and the tunnels cannot be drained to one or two points to be there run off or pumped up; there are, therefore, pumps at five different stations, the most important of them being at Govan. The working of these pumps, in order to keep the tunnels dry, means naturally a very large addition to the running charges of the system, but as experience has been gained the pumping is now better regulated, and will soon be done entirely by electricity.

PHOTO BY MACLURE, MACDONALD & CO.

A CAR INTERIOR.

Although the use of the cable was in the original design sent to Parliament, and was always favoured by Mr. Simpson and his partners, the Subway Company was not confined to cable traction by their bill. They were quite free to adopt any other mode of traction (except by steam locomotives), and some of the promoters were strongly in favour of electricity. It was, on the advice of Mr. David Home Morton, C. E., that cable traction was finally decided on. Mr. Morton, on being appointed consulting mechanical engineer to the company, addressed himself to a practical and exhaustive study of all the systems of traction in use in Europe and America, and found the balance of evidence distinctly in favour of the cable in the peculiar conditions on which the subway must work.

For electric traction the subway cars would have had to be made to overcome the steep gradients, incomparably more heavy than there was necessity for on the rest of the road. Then the circumference of the tunnels limits the height of the cars, so that sufficiently powerful motors could not be placed under them. This meant that electric locomotives would have had to be employed, and that implied more heavy rolling-stock and more heavy permanent way, and also more wear-and-tear.

By the cable system, on the other hand, the trains of cars, running in opposite directions, assist one another,—those going downhill helping to pull

those going uphill. By this principle of compensation much hauling power is saved, and it becomes more effective as the number of cars run is increased. Each additional electric car put on a route means a large addition to the working expenses, but each addition to the number of cars on the cable makes only a nominal demand on the horse-power. Thus the service on the cable system can be increased as the traffic requires, without appreciable increase of working expenses, while on the electric system every car put in motion becomes a heavy charge, whether it is earning money or not.

The cable system having been adopted, Mr. Morton proceeded to examine carefully all the cable systems at work in America, and out of his long and careful study of existing methods and machinery, he has evolved one of the best and most perfectly equipped cable systems in the world. While adopting every good idea he saw in use, Mr. Morton had to adapt, alter, and invent as he went along with the equipment of the subway. He had to contend with, or provide for, conditions which did not exist in any of the systems elsewhere at work. The Glasgow District Subway, as it is working to-day, is a striking monument of Mr. Morton's tireless energy, mechanical genius, and unfailing resourcefulness. The whole equipment was designed and constructed by him, and is still under his supervision as consulting engineer of the company.

The adoption of the cable permitted of the use of comparatively light rails on the track (60 pounds per yard), and of light rolling-stock. The sleepers of the permanent way, which is of 4-foot gauge, are laid on ballast, and the rails are spiked down to the sleepers without chairs. The distance between the top of the rails and the highest point of the roof of the tunnel is 9½ feet.

The permanent way is so planned as to place every station at the summit of a gradient of about 1 in 40, and this serves several good purposes. Thus, the stations are brought more conveniently near the surface; the up-grade assists the brakes in stopping the cars; and the down-grade reduces the pull on the cable when a start is made, and enables the start to be made smoothly and quickly. The cable is carried over 1700 track-sheaves in each tunnel. On the straight track the sheaves are verti-

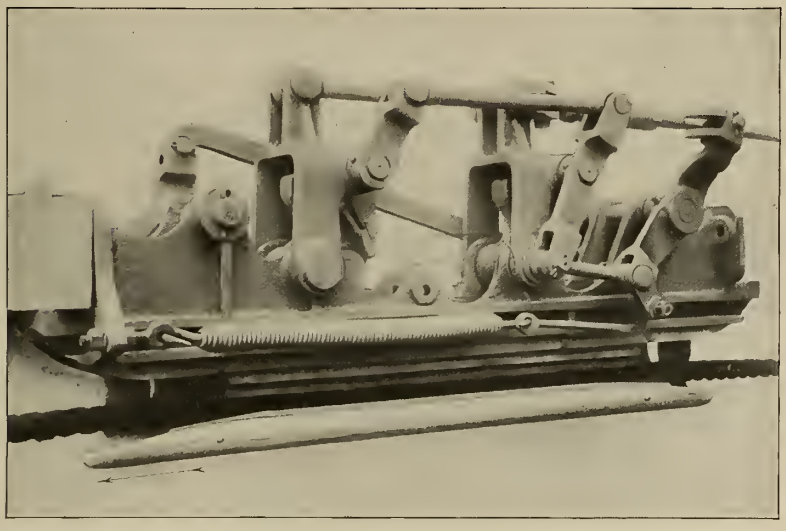
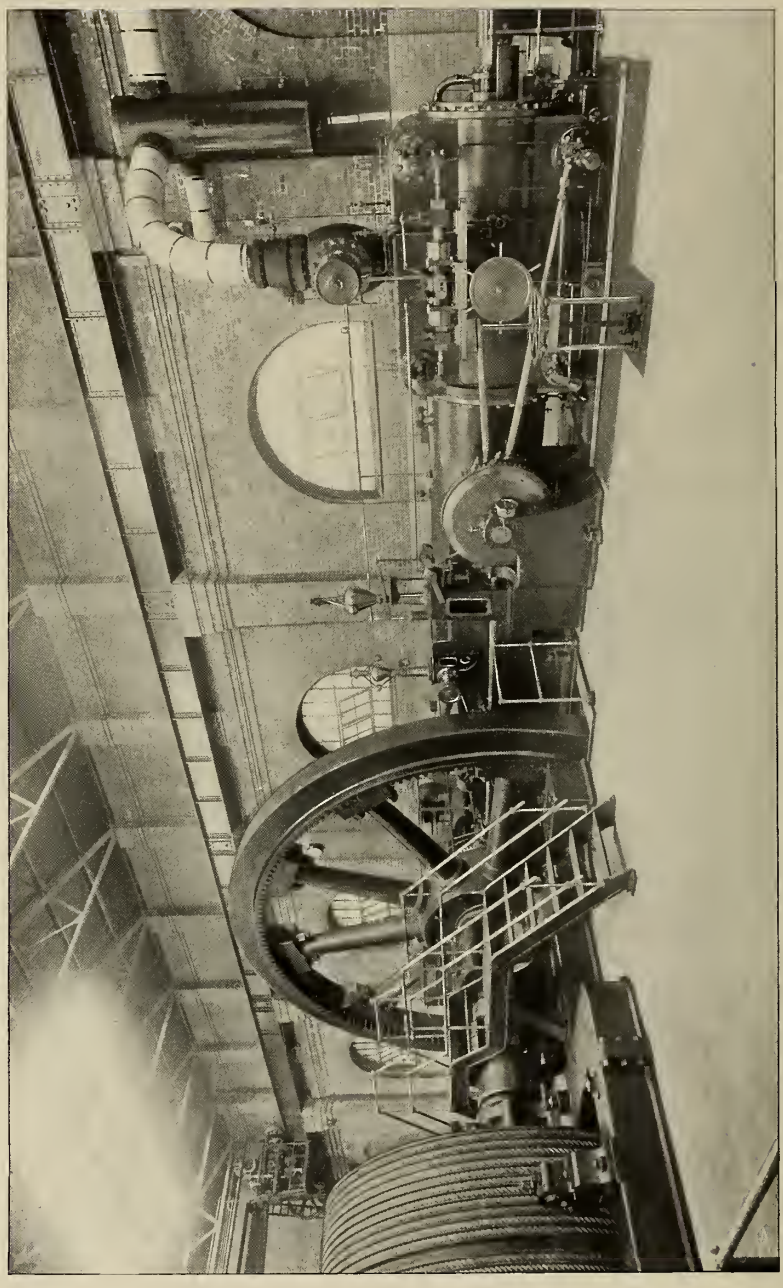


PHOTO BY MACLURE, MACDONALD & C°.

THE "GRIPPER."



ONE OF THE MAIN ENGINES.

PHOTO BY MACLURE, MACDONALD & CO.

cal and 30 feet apart; on long curves they are inclined; and on sharp curves they are horizontal.

On the sharpest curves both horizontal and inclined sheaves are used, at distances of eight or nine feet,—the distance apart increasing as the curve widens. These sheaves, having to revolve at a very high speed, are of special construction in each of the three types. They are all so designed that when screwed down on the track they carry the cable at a level of a couple of inches above the top of the rails. The cable is midway between the rails in the straight track, but on curves is two or three inches off the centre line, and towards the centre of the curve, so as to prevent the "gripper" from fouling the inclined and horizontal sheaves.

The cars, which were built by the Oldbury Carriage and Waggon Company, are of the double bogie type of American pattern. Each ordinary car weighs 9 tons, but trailer cars, slightly smaller and weighing 5 tons, are now attached, the two together forming a train with connecting gangway. The interiors are roomy, with plenty of headroom (6½ feet), and with so much space between the longitudinal seats that you do not rub against passengers' knees as you pass along.

The large cars are a trifle over 40 feet long, but a vestibule for the driver at one end and one for the conductor at the other, reduce the inside length to about 32 feet. These vestibules are shut off from the car by glass-panelled sliding-doors, which are opened by the driver and conductor when the car pulls up at a platform. Passengers enter by the rear door and leave by the door in the front. When the car starts the vestibule doors are shut, and thus all draught in the interior is prevented. The signal to start is given by the conductor to the driver by means of an electric bell, and the side doors at each end, giving access from the vestibules to the station platforms, are closed by iron lattice-work. Entry and exit are easy, as the car floor is on a level with the station platform. Both externally and internally the cars are attractive in appearance. The interior fittings are of polished teak, with oak panels; the roof is painted cream-coloured, relieved in gold and vermilion; and the general effect is bright and fresh.

The inconvenience of noise, inseparable from cable running, is reduced to a minimum by thick layers of felt, covered by linoleum, on the floor, and by felt under the seats. There are windows all along the sides and at the ends, although there is naturally not much to be seen in a tunnel, and although there was a little trouble at the outset, the cars are now admirably lighted by electricity on the trolley system. That is to say, the current is picked up by means of trolley wheels from two continuous conductors running along the side of each tunnel. There is sitting room in each of the large cars for 48 persons, and ample standing room for as many more without inconvenience to the sitters.

Though light, the cars are very strong, steel being largely used in the construction. Bogies and underframing are of steel, and the "gripper" is secured to the leading bogie under the leading axle. Between the bogies and the car body are four sets of steel springs, but there are no springs between the bogie and the axle boxes, so as to leave room to keep the "gripper" clear of the track sheaves.

The gripper is, of course, the most important part of the car equipment, and may be described, generally, as a powerful vice, secured to the underframing, and operated by screws or levers, gripping the cable in such a way as to impart its motion to the car. The subway grippers differ from those used on the street cable lines, inasmuch as the latter have to be dropped into the conduit below the surface, while on the subway the cable runs above rail level, and the lowest part of the gripper is several inches above the top of the rails. The gripper is fixed parallel to the rails, under the forward axle of the leading bogie, enabling it to travel on the centre line between the rails; the bogie thus acts as a motor, guiding the long car.

Of the jaws, between which the cable

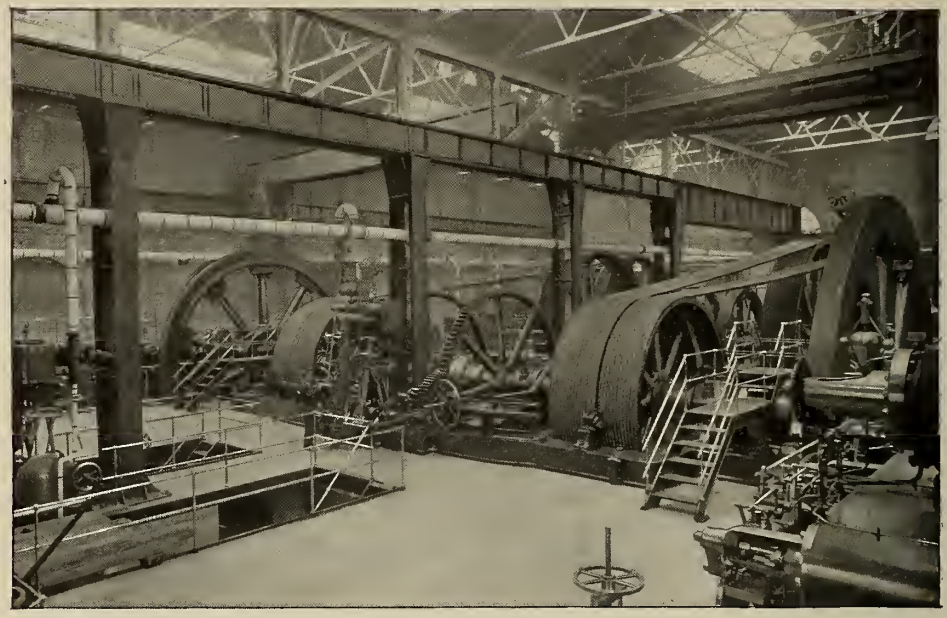


PHOTO BY MACLURE, MACDONALD & CO.

THE POWER STATION INTERIOR.

is clamped, the lower is fixed, while the upper can be raised or lowered at the will of the driver. The cable, which must at times leave the gripper, can always be discharged from one side. The jaws, being subject to considerable wear, are fitted with renewable dies of rolled steel, giving effective lengths of 2 feet, 4 inches, and 2 feet, 9 inches, respectively, for top and bottom jaws. The upper jaw is brought down on the rope by an arrangement of links and levers, connected by chains to the driver's wheel in the forward vestibule.

The gripper appears, at first sight, to be a very intricate piece of mechanism. The apparent complication is, in reality, due to the trip-gear for the discharge of the cable from the jaws and to the duplication of levers, because of the unusual length of these jaws. The trip-gear consists of a very ingenious arrangement of links, pawls and levers, whereby, even if the gripper is being held hard on by the driver's hand-wheel, the top jaw can be suddenly released and allowed to rise on springs clear of the cable, this act being followed by the lifting of two small discharge bars, which, in turn, raise the cable and throw it free of the gripper.

This gear is operated generally by means of a hand-lever by the driver; but should he omit to use the lever at certain points where the cable is to be released, a small roller on the forward end of the gripper comes in contact with a long cam-bar fixed between the rails, and causes the gear to act precisely as if the lever were used. At the passenger stations the cable is not thrown out, but simply runs on the lower die of the gripper, the top jaw being raised a little out of contact.

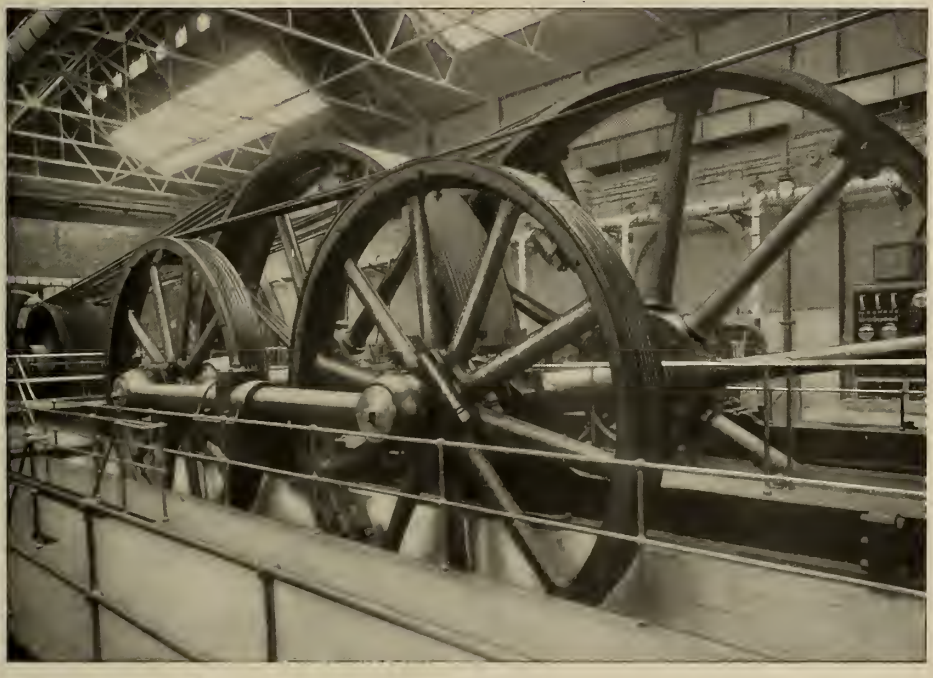
The passenger stations are fifteen in number. A penny fare covers four stations, and a twopenny fare covers the whole of either circuit. The original intention was to have a universal penny fare and no tickets, the fare to be paid at an automatic turnstile on entering a station,—and probably this design will be ultimately carried out. It was, indeed, tried for a time, but was found to be abused by idle persons, who, having once paid, went on round and round the circle, either for the fun of the thing or for the pleasure of cheating the com-

pany. It is a question whether the great saving to be effected by dispensing with ticket-clerks and collectors would not more than compensate for any loss in that way, which, though it might be considerable when the thing was a novelty, is not likely to be much now that the subway is thoroughly familiar.

Six of the subway stations are quite underground, and have to be always electrically lighted; the others are open to daylight and have glass roofs. All of them have island platforms, about 10 feet wide, on a level with the car floors, and access to the street is by means of stairs and corridors, lined with white tiles and electrically lighted. At one station (Kelvinbridge) there is an electrically worked elevator for the use of passengers between the street and the platform, and it is intended that similar elevators will, in due time, be supplied at some of the other stations.

So much, then, for the line and its equipment. The power station is situated on the south side of the river, in a district of the city chiefly given up to engineering. The main engine-house is 138 feet long, 100 feet wide, and 31 feet high from floor to roof. Heavy cast-iron columns run down the centre to assist in carrying the girders for two 25-ton travelling cranes. The main engines are in duplicate, placed on each side of the centre line of the engine-house, but though one may be used for each tunnel, it is found that one is sufficient for the traffic in both tunnels. One engine, therefore, is always kept in reserve, and the engines are run alternately, week or fortnight about.

Each engine is of the horizontal single-cylinder, non-condensing type, with Corliss valves. The cylinder, which is steam jacketed, is 42 inches in diameter, and the piston has a stroke of 6 feet. The steam inlet valves are actuated by means of an eccentric and rod independent of those which work the exhaust valves, while, owing to the distance from crank-shaft to valves, the eccentrics run on a counter shaft. The ponderous flywheel, 25



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THE CABLE-DRIVING DRUMS.

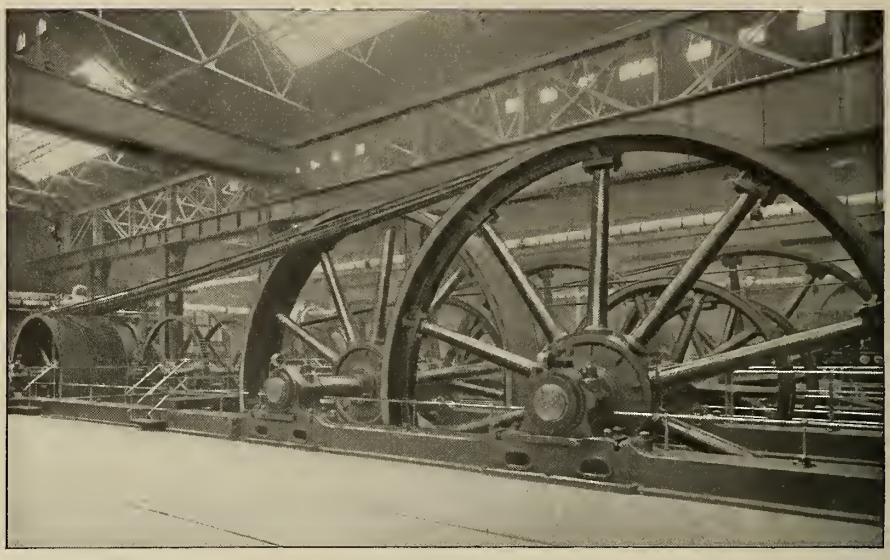


PHOTO BY MACLURE, MACDONALD & CO.

THE ROPE DRIVE.

feet in diameter, weighs 50 tons, being built up of cast-iron hub, arms, and rim segments.

To give the maximum speed of 15 miles an hour to the cables, the engine, which is capable of developing 1500 H. P. economically, runs at 55 revolutions per minute. Two governors are provided, the larger acting on the valve gear, and the smaller on a throttle or butterfly valve immediately above the main steam inlet valve. These two

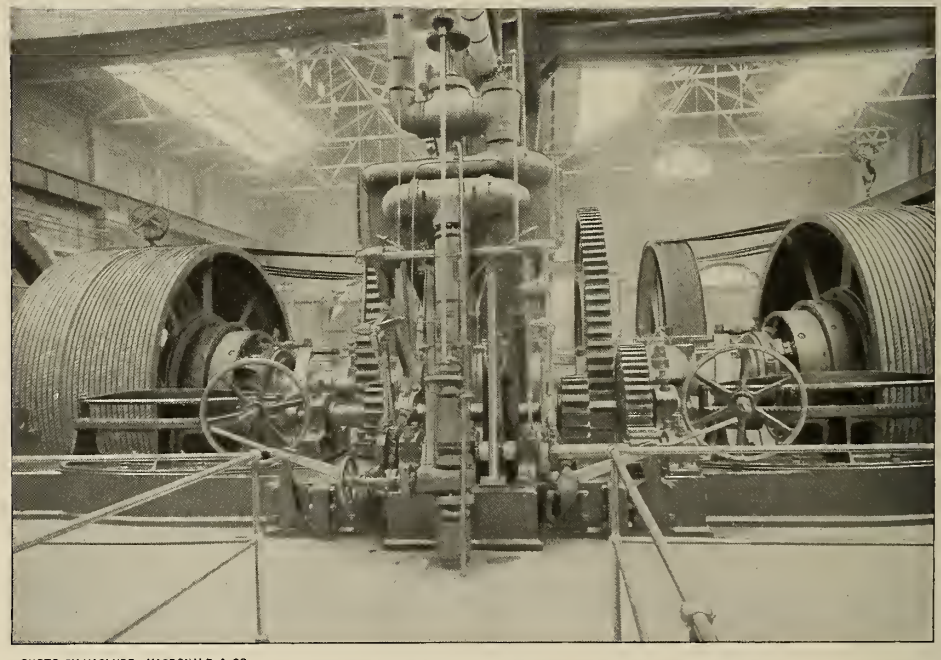


PHOTO BY MACLURE, MACDONALD & CO.

THE ROPE DRUMS, FRICTION CLUTCHES, AND BARRING ENGINE.

governors act quite independently of each other. Midway between the two large engines is a vertical, double-cylinder engine, 14 inches in diameter by 18 inches stroke, which serves as a barring engine to assist in starting its big brothers. It is also of service for examining and repairing cables and machinery, giving a slow, steady motion, either backward or forward, under circumstances when the use of the big engine might be attended with danger. In threading the first cables, this small engine proved a valuable assistant.

Across the house runs the main driving-shaft, made in two lengths, and ranging in diameter from 18 inches to 21 inches, with all the necessary bearings and couplings arranged so that the shafting may be run by either or both engines, or that in the event of one of the cables having to be temporarily stopped, the other can be kept going. Running loose on each section of this shaft is a 26-groove rope drum, 13 feet, 9 inches in diameter.

Power is transmitted to it by means of a Walker-Weston multiplate friction clutch. This clutch consists of a series of annular plates, which are attached alternately to a casing fixed to the drum and to a sleeve fitted to and driven by the shaft. These plates are held by keys so that they cannot revolve independently of the casing or the sleeve to which they are attached, but all can slide to a certain extent parallel to the axis of the shaft. To set the drum in motion it is only necessary, by means of a hand-lever and rack and pinion arrangement, to press all the annular plates together, causing great friction between them.

The clutch-driven drum, in turn, drives two 25-foot diameter rope drums, each of which is mounted on a separate shaft, one being 18 feet in advance of the other. Of the twenty-six cotton driving ropes, which are each 2 inches in diameter, fifteen drive the first drum. Owing to the method of wrapping the steel cable on its driving-drums, the first, of necessity, does more than the second, hence the cotton rope drum which drives the second takes eleven ropes only.

A 14-foot diameter cable drum is fitted on the overhung end of each of the 25-foot drum-shafts. These are differential drums of the Walker type, with six grooves, and together drive one of the haulage cables. They are set in line so that the bottoms of the grooves of one drum are opposite to the ridges of the grooves on the other, to divide the angle of divergence in wrapping the cable. A massive strut, with wedge adjustment, between the shafts, counteracts the tendency of the cable to bring the drum-shafts towards each other.

The Walker differential drum overcomes the difficulties ordinarily experienced through the stretching and slipping of the cable and the wearing of the grooves. Coming up from the road the cable runs up the cable culvert to the under side of the differential drums, and after taking the requisite number of turns around them, runs off to a 14-foot sheave on the tension carriage, from which its direction is changed down the culvert again to the road. The tension carriage can take up a stretch of 300 feet.

The tension varies, of course, according to the number and position of trains on the cable at a time, and an Upton tension regulator is applied to meet the variation. This regulator consists of a variable number of plate-weights, slung by four long links, two of which are fixed to the anchorage, and two to a small four-wheeled carriage running on the same rails as the tension carriage, and connected to it by means of a wire rope. As the regulator carriage moves to and fro, owing to the varying pull on the cable, the weights rise and fall, and their effective value varies as the angularity of the links.

As the cable comes down the culvert on to the track it is diverted by means of a 12-foot sheave, which is placed under the rails and slightly out of the horizontal. From this 12-foot sheave the cable passes over five 30-inch vertical sheaves, which are pretty close together, and which elevate the cable

about 7 inches above the rails, from which it falls back to the normal working-level of 2 inches. On returning to the station, of course, the operation is reversed, and the *modus operandi* is the same for both tunnels, with the necessary difference in deflection.

The boiler house equipment consists of eight Lancashire boilers, 8 feet in diameter and 30 feet long; but only four, or at most six, are ever in use at one time. Boilers and fittings are constructed for a pressure of 120 pounds per square inch, but the regular working pressure is 100 pounds. Vicars mechanical stokers are used, and also a coal elevator connecting with the stores beneath, power for these being furnished by an 8½ by 9-inch Robey high-speed engine. Over the boilers there is a maze of pipes, all neatly clad in magnesia covering, painted white. The whole place is scrupulously clean and bright.

The drudges of the system,—the cables themselves,—are well worth attention. They are each 1½ inches in diameter and 36,300 feet in length, and are made up of six strands, of from 13 to 16 wires per strand, laid on a hemp core Both the wires and the strands are laid from left to right and not in opposite directions, as in the ordinary "lay," and thereby a greater wearing surface is presented. Each one of the cables contains about 600 miles of steel wire, and when splicing is necessary, a length of about 80 feet is taken for the splice. Splicing is carefully taught in the yard, where old cables are kept for the practice of the men, and rewards are given for proficiency in the art.

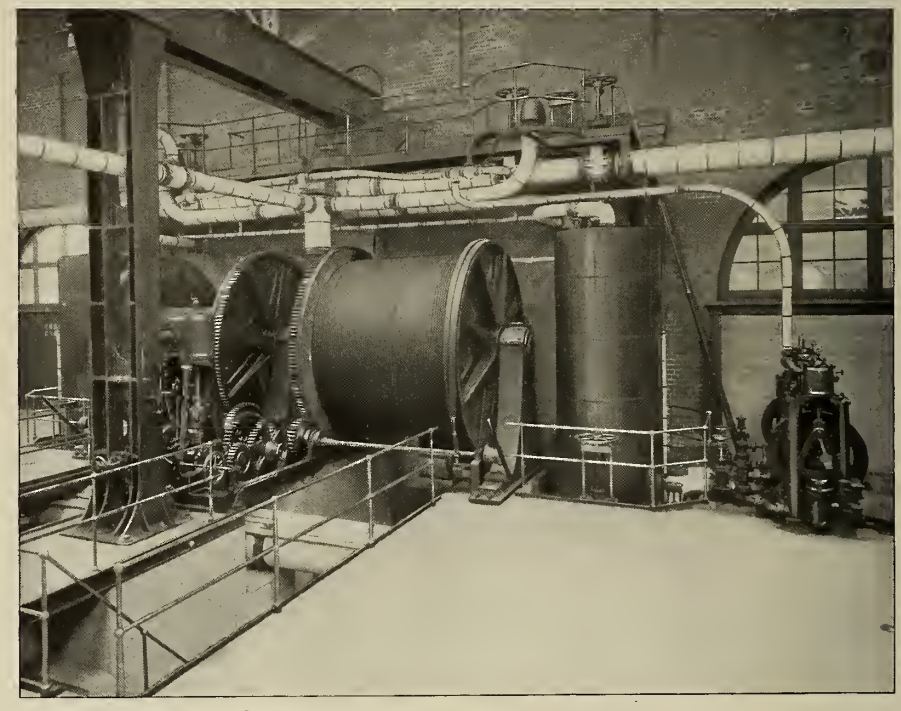


PHOTO BY MACLURE, MACDONALD & CO.

THE STORAGE DRUMS, FEED WATER HEATERS AND PUMPS IN THE POWER STATION.

Each cable weighs about 57 tons, and one of the problems to be solved was how to get such a weight transported from the cable makers' works in the north of England to the power station. Each of the four makers who have supplied cables has adopted a different method of transport, but this is an in-

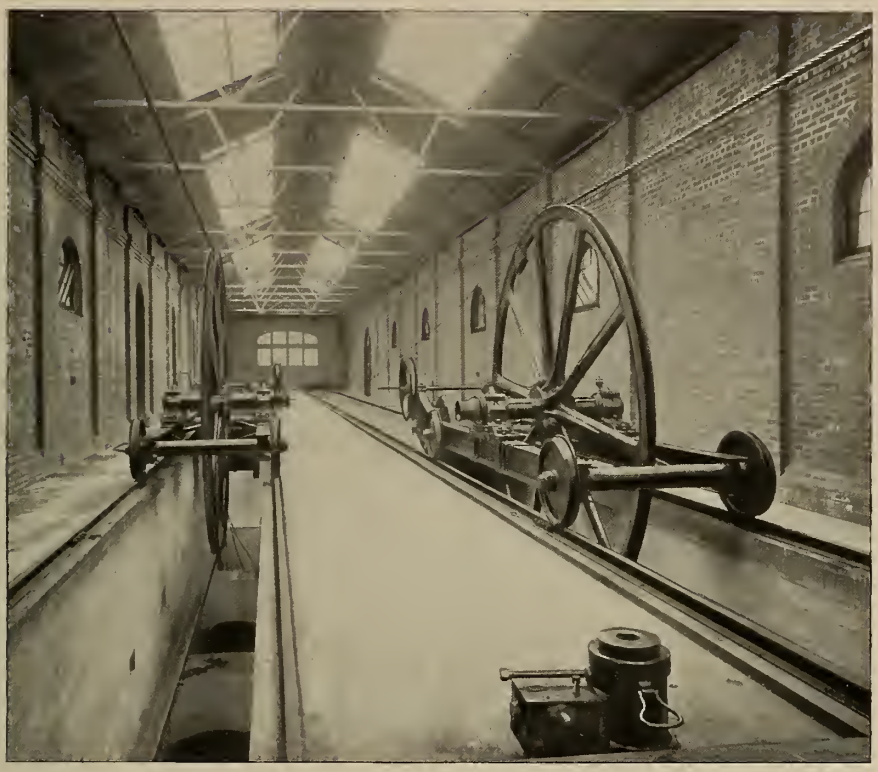


PHOTO BY MACLURE, MACDONALD & CO.

THE TENSION CARRIAGES.

teresting part of the story which hardly belongs to the present purpose.

At the power station is also the electric plant for lighting the whole of the line, and working pumps, elevators and other auxiliary apparatus. It consists of four Silvertown continuous-current dynamos, each coupled to a compound vertical Belliss engine with 9-inch high-pressure and 15-inch low-pressure cylinders, the stroke being 9 inches. The dynamos are of the inverted horse-shoe type, and each is capable of developing 79 kilowatts, or about 106 electric H. P. Throughout, the wiring is done on the three-wire system.

The car shed is apart from the power station, and is situated near the Govan Cross station of the subway. It is not the least interesting feature of the system, for here is a most ingenious appliance for lifting the cars bodily from, and for placing them onto, the track, without stopping the cable or interrupting the traffic. The tunnels pass right under the car shed, and access to them is through a shaft or pit, 55 feet long and 28 feet wide, and 20 feet deep, through which the cars are lifted or lowered by means of a 12-ton travelling crane. This crane acts both as an elevator, a turntable and a traverser,—lifting the cars, carrying them where required, turning them, and dropping them on to any desired line of rails. The shed is 220 feet long and about 115 feet broad, with a storage space of over 25,000 square feet.

Between the rails, on which the cars are placed when hoisted up from the subway, are 3 foot pits, to permit of the inspection, cleaning and repair of the under-frames and grippers. The cars cease running at 11 P. M., and as each completes its run, it is taken into the car shed for the night. In case of damage or accident to any car on the circuit it can be run (or if its own gripper is dis-

abled, it can be pushed by the car behind) to the car pit and there taken off the line without delaying the traffic more than a moment.

Although the system is worked according to Board of Trade regulations, on the block system, that system is practically automatic and signalmen are dispensed with. At each station there is a semaphore, at the end of each of the tunnels as it opens out into the arch. These show red and green lights, which signify to the driver of the incoming car whether the line in advance of him is clear or not. When the preceding train has left the station in advance the starting signal is given, and as soon as the train has gone its own length into the tunnel it passes over a treadle which breaks the electric contact and sets the signal behind at "danger," at which it must remain until the train, on passing the next station, acts on another treadle, which releases the danger signal and shows the line to be all clear between the two stations.

The stations are also connected by telephones and electric bells, and each station is also in communication with the power station, and can signal for the stoppage of the engines there in case of need. Practically, then, the "blocks" are the stations, and therefore the frequency with which trains can be run is limited by the distance between the blocks, as no train can leave a station until the train in advance is starting from the next station.

At present the trains are run at intervals of three and a half minutes, and this is about as close as they can get under the present arrangement of blocks. A more frequent service, however, could be maintained were the signals put midway in the tunnels between stations. And here it may be mentioned that, although the Board of Trade insist upon this blocking and signalling, many competent authorities think the whole system unnecessary and unnecessarily expensive. It is argued that the cars do not run at a rate of speed which would permit of any serious accident, even if one did run into the rear of another. And they cannot run into each other going in opposite directions. Each car is furnished with such powerful head-lights that the driver can see a long way ahead, and could always stop his own car before he could run into a disabled one ahead.

In relation to the street tramways the subway is undoubtedly handicapped. The working charges laid upon the subway (which do not fall upon the street tramway) in respect of the Board of Trade regulations, the blocking and signalling, and the limitation of trains by the block, are very onerous. And then the subway has heavy special expenditure in connection with lighting and pumping; while, being a novel undertaking, the staffs in all departments are kept much larger, and therefore at more expense, than there will be need for when every item in the system has been thoroughly tested by experience. Yet with all these financial drawbacks in comparison with competing systems, the subway is not only paying, but promises to be a highly remunerative undertaking as traffic increases and working expenses are reduced, as they are sure to be in the near future.

As a means of locomotion the subway is comfortable, for the movement of the cars is without spasmodic jerks, and the gradients are scarcely felt. There is necessarily some noise from the running of the cable, but it is minimised to something very much less than that on probably any other underground railway. The steady weekly increase in the traffic receipts may be taken as proof of the growing popularity, and therefore efficiency, of the service.

DISCHARGING A TORPEDO.

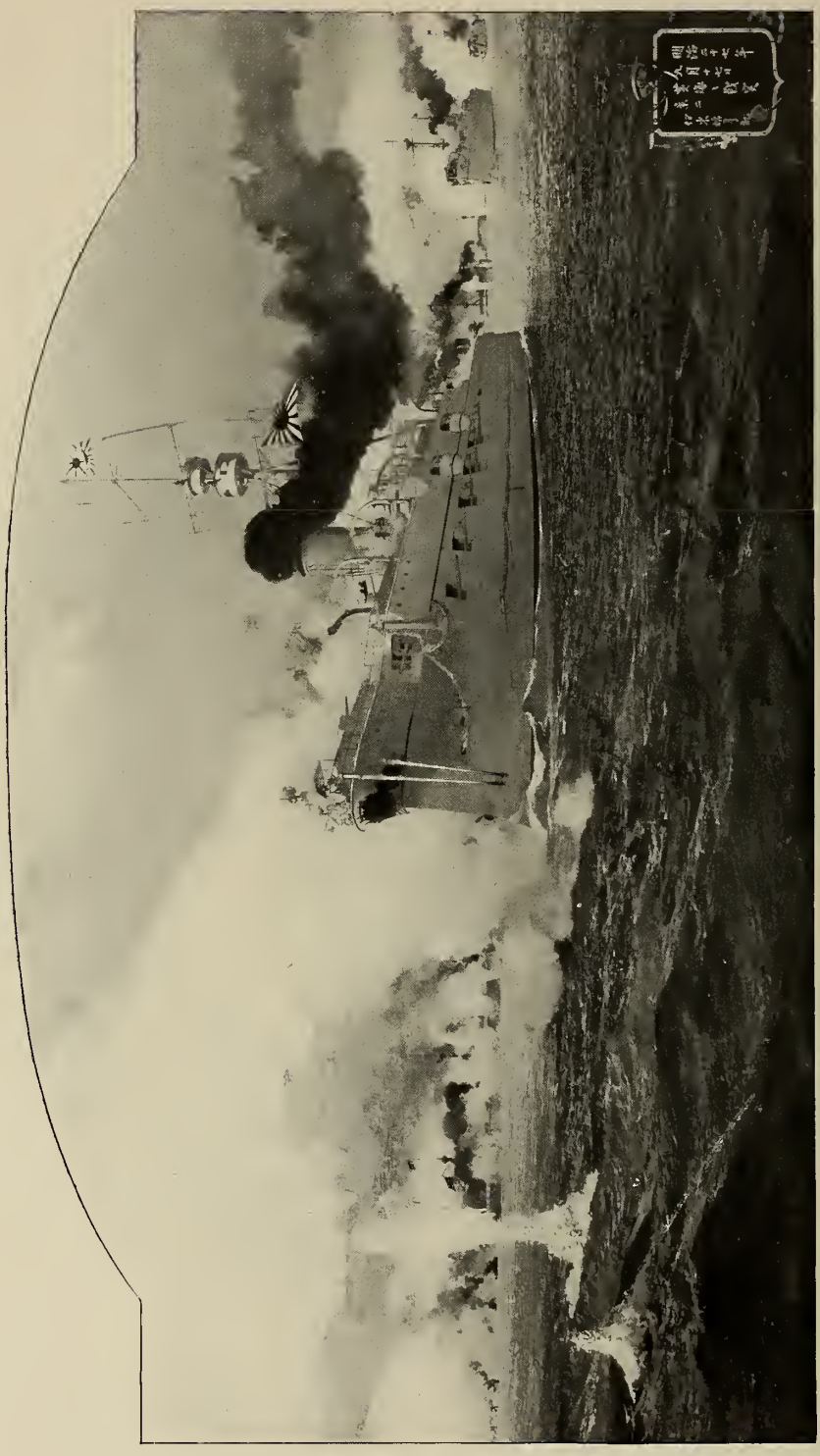
TORPEDO-BOATS IN MODERN WARFARE.

By Captain William H. Jaques.

THE great number of articles recently written about torpedo-boats and torpedo-boat destroyers, many of which have appeared in this magazine, and the variety of opinions that have been expressed regarding their value in naval warfare, make it a matter of grave doubt whether the United States should pursue the course authorised by the late Congress, under its naval appropriation bill, to build twelve torpedo boats and sixteen torpedo-boat destroyers for the United States Navy if they are to be duplicates of those which are now under construction.

An examination of the chief characteristics which have been submitted to the public for bids to be opened shows, in general, that the details of the latest European types are to be followed. When, in the course of a year or eighteen months, these twenty-eight craft shall be finished, we will then have but a handful, and they of a class of which the leading maritime powers have greatly superior numbers, and all of a type that, in the only two naval wars from which we could gain experience, have shown themselves of little, if any, value. In fact, in the present war with Spain all of the enemy's torpedo-boat destroyers or torpedo-boats that have put in an appearance have been quickly destroyed or disabled, and the loss of life on board the United States torpedo-boat *Winslow* in its one reconnoissance was greater than that of the combined East and West Indian fleets of the United States which so expeditiously destroyed the flower of the Spanish Navy.

Early in 1896, just after the writer's return from Japan, which country he had visited to learn, by personal inspection of the ships engaged in the China-Japan war, the results of the naval engagements of Yalu and Wei-hai-wei, he gave, at the request of United States Senator Hawley, the following information which was subsequently used by



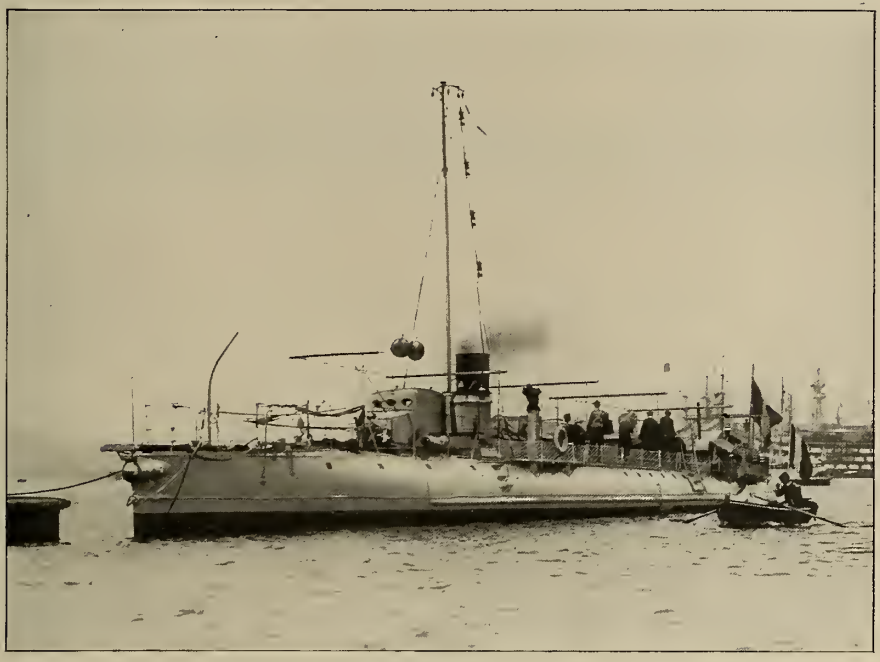
THE BATTLE OF HAIYANG, OR YALU, BETWEEN THE JAPANESE AND CHINESE, ON SEPTEMBER 17, 1894.

Senator Chandler when the torpedo-boat item of the Naval Appropriation Bill of 1896-'97 was under debate:—

"If it is to be the policy of our government to employ torpedo-boats as one of the units of defence, they should be provided by the hundred, and simple, efficient requirements demanded, leaving the details to private builders. By this method most excellent results will be obtained, as far as time, price and efficiency are concerned. A contract for torpedo-boats of less than three or four hundred tons.

"While these craft have received various names, such as torpedo gun-boats, torpedo-boat destroyers and torpedo-boats of various classes, they are provided for the purpose of destroying ships with torpedoes, and the increase in size and powers of offence and defence is a very natural one.

"Great Britain has recently added to her navy forty-two torpedo-boats,



A FRENCH TORPEDO BOAT.

fifty or a hundred would give the country something more than a few unsatisfactory experiments, which more than describes our present torpedo-boat force.

"The present combined torpedo flotilla of Great Britain, France, Russia and Germany exceeds a thousand of the various types. Experiment and service in foreign countries have demonstrated the mistake of building these craft too small and of too low speeds. Great Britain, particularly, has made a most radical departure, and there is every evidence that she will build no more distinguished by the name of torpedo-boat destroyers, of a tonnage of from 260 to 300, the majority of which have a speed of from 28 to 30 knots. These torpedo craft have a horse-power of from 3000 to 4000, and their average cost was £38,000 (about $190,000), £15,000 of which is for hull, including mast and rigging, £22,000 for propelling and auxiliary machinery, including air compressing plant, and £1000 for rapid-fire batteries. The latest first-class torpedo-boats built by Great Britain have a displacement of 130 tons, horse-power 2000, and speed of 26

ANOTHER FRENCH TORPEDO BOAT UNDER WAY.

knots, and were built at an average cost of £15,000 (about $75,000)."

While the situation in regard to torpedo-boats at that time led the writer to believe that there must be some modification of the type, the experiments in the United States and France with submarine boats had not reached a stage to justify the conclusion that their characteristics should be embodied in torpedo craft to secure the greatest advantage of torpedo attack. The writer believed, as appears in the above data, that if it was to be the policy of the United States government to employ torpedo-boats as one of the units of defence, they should be provided in very large numbers and the details should be largely left to private builders.

At the beginning of this year the developments and improvements in the submarine torpedo-boat system so fully justified the writer in taking a definite position in relation to the value of submarine torpedo-boats that he presented a paper on the subject to the British Institution of Naval Architects. The subject was discussed from many points and a general review was presented of what had been accomplished in submarine craft; but the writer would repeat here only what he specially emphasised in relation to the influence of submarine-boat principles on present torpedo-boat architecture.

It was pointed out that the development of the submarine-boat, its power to disappear, its ability to move quickly, its valuable element of submergence, the practicability of protecting by armour its limited visible portion, and the surety of its fish-like qualities, must have a radical influence in modifying the present types of torpedo-craft, no matter whether it replaces the second-class torpedo-boat on board a battleship, whether it is employed for submarine purposes pure and simple, or, as most probably will be the case, whether its submarine principles are utilised to protect the semi-submerged torpeo-boat and to meet the practical conditions sought for in combining such invisible and protective qualities as will enable the torpedo-boat to surely get in her work. Most torpedo destruction has been done with a bag of explosive on the end of a pole, and the submarine-boat will permit you to get closer to the enemy, with a bigger bag of explosive, and with less danger to the pole.

If the chances of the ordinary tor-

pedo-boat are compared with those of a submerged-boat for landing a torpedo, there certainly can be very little doubt as to which is the more hazardous. A large number of successful trials have proved that, by the suggested modifications, you will get all the advantages of attack, with almost absolute safety to the torpedo-boat itself.

If there are no other elements of value in the submarine-boat than its influence in modifying the present type of torpedo-boat, this alone should certainly give it prominence and weight,—a powerful influence which certainly cannot be ignored. So much has been written about the accomplishments of the submarine torpedo-boat *Holland* that, notwithstanding its very great popularity throughout the United States, the writer will not again describe her details or characteristics, or give the results of the tests, but rather lay before the magazine's readers a concise history of the part taken by torpedo-boats in the China-Japan war and up to the present time in the war between the United States and Spain.

A SPAR TORPEDO BOAT.

While all naval powers appear to have agreed that battle-ships, cruisers and torpedo-boats should be the principal elements of their squadrons, the two modern wars from which so many valuable conclusions have been expected, have not demonstrated that the present types of torpedo-boats or torpedo-boat destroyers were capable of accomplishing the great results that were expected of them, for even in the cases of the four Chinese ships, torpedoed in the Wei-hai-wei engagements, they had first been severely injured by the Japanese quick-firing batteries.

From the Japanese reports of the naval engagements of the China-Japan war of 1894-'95 we learn that no Japanese torpedo-boats were in action at the battle of Haiyang, or the Yalu, as it is sometimes called, those that belonged to the main squadron having gone up the Taidong river to assist, if necessary, in covering the army in crossing the river in the attack that had already commenced upon Phyongyang. Of those engaged on the Chinese side, we find record of but one attempt on the part of the torpedo cruiser engaged, the *Kwang-Ping*, to use her torpedoes, she having missed the merchant cruiser *Saikyo* and subsequently fled for safety. A torpedo-boat joined in this attack, but did no service.

From the larger ships but three torpedes were used. Two, fired from Chinese barbette ships, failed to strike the Japanese cruiser *Hiyei* when she boldly passed through the Chinese line, while the third was used by the Japanese to destroy the stranded *Yangwei* when they returned next morning to the previous day's scene of battle, the larger part of the Japanese squadron having kept at a distance from the retreating Chinese, fearing a night torpedo attack. The Chinese were, how-

ANOTHER VIEW OF THE YALU BATTLE.

ever, bent on a retreat and did not make the attempt.

In the part assigned to the Japanese fleet for the capture of Wei-hai-wei sixteen torpedo-boats were divided into three flotillas, the Japanese report of which is interesting. Port Arthur fell on November 21, 1894. During the month of January, 1895, one hundred transports carried the Japanese forces for the capture of Wei-hai-wei. By February 2 Wei-hai-wei had been entered and all the Chinese positions had fallen into the hands of the Japanese, except the island forts, the capture of which and the remaining Chinese ships was left for the Japanese navy to accomplish.

Although the Japanese fleet engaged the Chinese ships and forts, it was not until February 4 that instructions were given to the torpedo-boats for a night attack. The first flotilla was composed of torpedo-boats Nos. 7, 11, 12, 13, 23 and the *Kotaka;* the second of Nos. 8, 9, 14, 18, 19 and 21; and the third of Nos. 5, 6, 10 and 22. All of these boats, with the exception of the *Kotaka*, had a displacement of 56 tons, were 115 feet in length, had an estimated speed of 20 knots, and carried one-pounder rapid-fire guns in addition to their torpedo armament. The *Kotaka* was built by Yarrow in 1886, was of 190 tons displacement, 166 feet long, had 1400 indicated horse-power, 2 screws and a speed of 19 knots, and carried 4 machine guns, in addition to her 6 torpedo tubes. The Chinese torpedo-boats varied in size from 28 to 128 tons, with speeds from 18 to 24 knots; all were armed with quick-fire, revolving, or Gatling, guns, in addition to their torpedo tubes.

The operations of the torpedo-boats in the naval encounters of Wei-hai-wei are succinctly described by Mr. Jukichi Inouye. He says that on the night of February 4 the Japanese torpedo-boats Nos. 6 and 10 succeeded in cutting away 325 feet of the boom across the entrance to the harbour, though they were fired at from the forts on the island. About 3 o'clock on the morning of the 5th, after the moon had gone down, the third and second torpedo flotillas passed the forts and entered the harbour through the breach made in the boom.

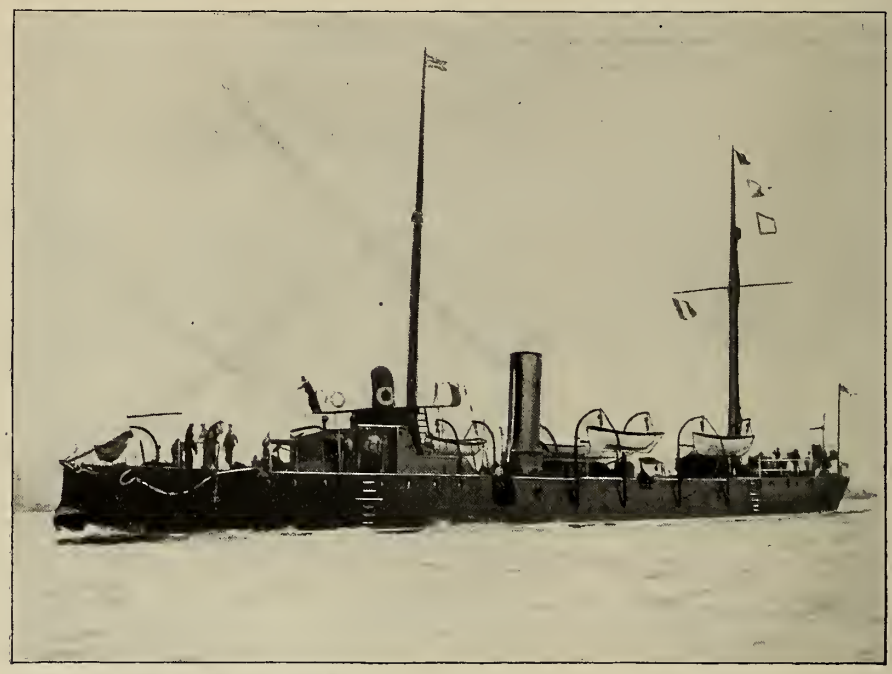
DAMAGE CAUSED BY A GALE TO THE SPANISH TORPEDO-BOAT DESTROYER "AUDAZ"

The Chinese men-of-war lay before Liukung island while a gunboat and a torpedo-boat kept guard. Torpedo-boat No. 22 was discovered as she came close to the men-of-war, but she man-

aged, in the confusion caused by her presence, to discharge two torpedoes. She was so severely attacked, however, that she made immediately for land and ran aground. One of her crew was killed and several others were drowned. After a canvas-boat, which had carried part of the crew ashore, had overturned and there was no other help, the rest in the torpedo-boat, including Lieutenant Fukushima and five others, remained in the hold while the boat was exposed

men in the engine room were wounded. She was completely disabled, but had the good luck to have her crew rescued by torpedo-boat No. 19 before she was abandoned. Nos. 8 and 14 had stranded. The *Ting-yuen* had been hit, and another had foundered in shallow water. It was decided to make a second torpedo attack that night, though the Chinese were now on the alert.

On the 6th the first flotilla went into



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THE BRITISH TORPEDO-GUNBOAT "RATTLESNAKE."

to the enemy's fire. They were rescued in the evening.

Torpedo-boat No. 9, of the second flotilla, on taking her course to the northwest, ran close to the *Ting-yuen*. She got among the Chinese torpedo-boats, which failed to recognise her until a light was thrown upon her from the men-of-war. She discharged a torpedo at 200 yards and another at 50 yards, and as the latter took effect she retreated at full speed; but the Chinese poured a heavy fusillade upon her, by which four men were killed and all her

the harbour at 4 o'clock in the morning. Three Chinese vessels were hit with torpedoes; and though the flotilla was subjected to machine-gun fire, it was not damaged. When day broke, the *Lai-yuen*, *Wei-yuen* and a transport were seen to be half sunk.

During the attack on Liukung island on the 7th by the Japanese squadrons, ten Chinese torpedo-boats and two steam launches came out of the harbour and were pursued by the first flying squadron. Eight of the former and both launches ran aground, but the re-

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THE BRITISH TORPEDO CRUISER "ARCHER."

maining two entered Chefoo, which, however, they left immediately after and also ran aground. They were brought to Yinshankow by the Japanese cruiser *Yoshino*. Most of the crews of these boats, on deserting them, were captured by the army. Operations for the destruction of the boom were conducted on the 8th, 9th and 10th by a tender and a boat sent from each of the four men-of-war composing the flying squadron. The torpedo-boat flotilla does not seem to have taken part in the final destruction of the boom.

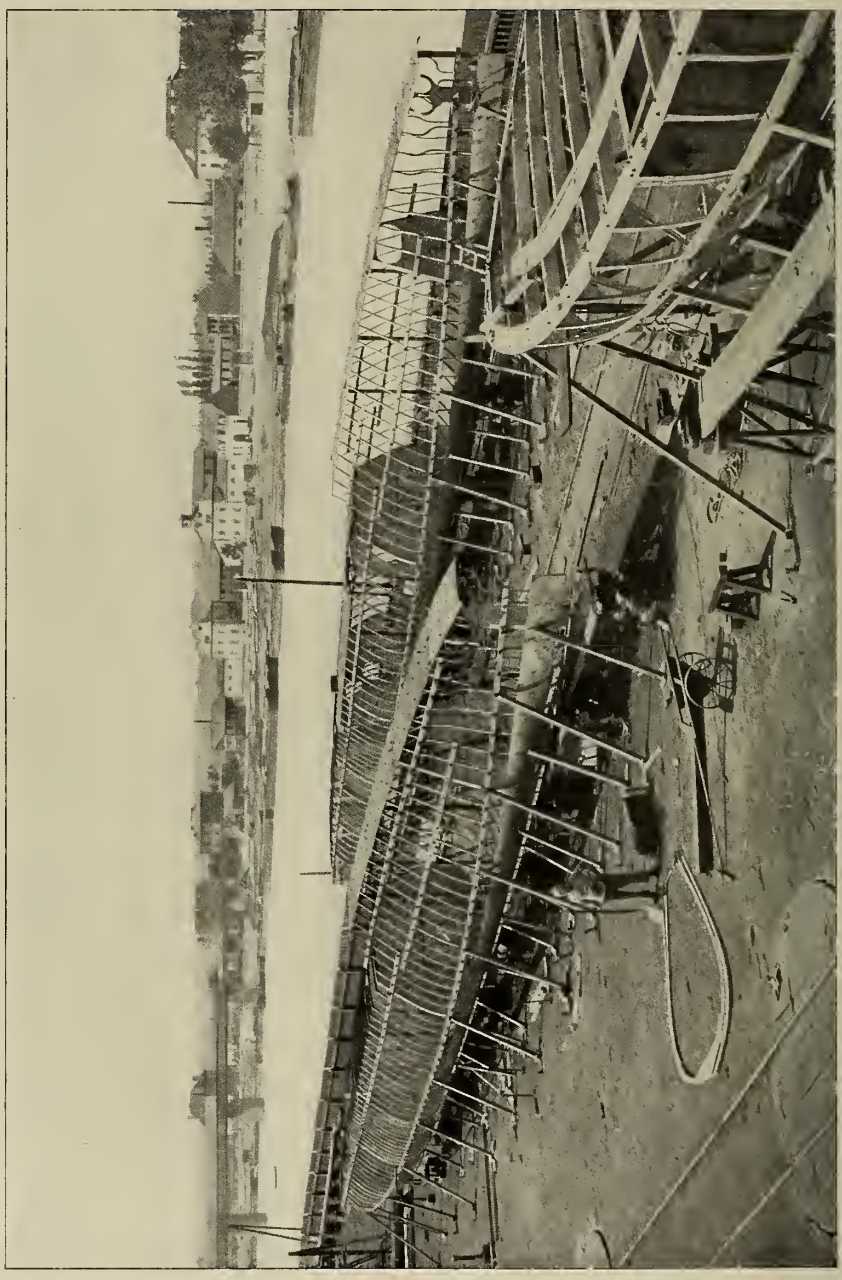
All the torpedo engagements of the present war with Spain have shown the necessity for the characteristic of invisibility, each attempt by Spain and the United States having demonstrated the superiority of the rapid-fire or rapidly served guns. Although Lieutenant Commander Wainwright's success in destroying two Spanish torpedo-boats confirms Admiral Colomb's opinion that exceptional courage, coolness and judgment generally win, it proved the contrary of the superiority of rapid-fire guns, for the superior armaments of the two destroyers which were attacked by the U. S. S. *Gloucester* were no match for the persistent fearlessness with which this little unprotected yacht, with a lighter battery, dealt the final death-blows.

Surely, all these examples serve to show that we must seek a type of torpedo-boat that will comprise those elements in a torpedo-boat which are requisite for success with the least possible loss of life.

The success of the unprotected yacht *Gloucester* appears to have suggested the use in Cuban waters of some of the many small craft acquired for a coast guard, but it is reported that the *Manley*, the only torpedo-boat in the United States auxiliary fleet, will, if used, be assigned to dispatch duty, as she is too small to carry a service torpedo tube. The *Manley* was bought of Mr. Yarrow, but is apparently too small to be used for other than spar torpedo work. Furthermore, her speed is not great.

If the object of the United States Navy Department is to cut out the Spanish craft which have taken refuge within the range of the guns of the fortifications, could not the submarine-boat be used with less risk to life, having the ability to attack in succession without being seen and effecting such character of disability to the enemy as would admit most readily of reclaiming the craft torpedoed? The moral effect alone of its presence might decide surrenders.

If anything has been demonstrated during this war it is the efficacy of sub-



FRENCH TORPEDO-BOATS IN COURSE OF CONSTRUCTION AT THE WORKS OF MESSRS. SCHNEIDER & CIE., CREUSOT, SHOWING THEIR FRAILTY.

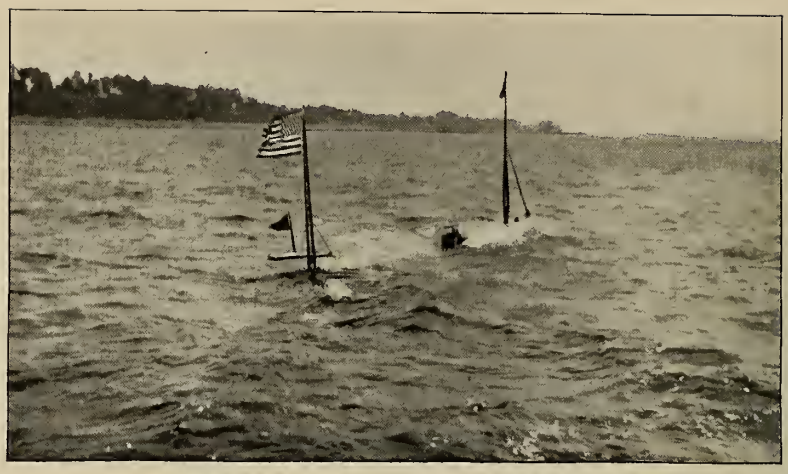
marine mines. The submarine boat, therefore, if used only as a mine, has the great advantage of mobility over immobility, the great value of which is so often and well urged. This is but one of its great values. It comprises, in addition, all those essential elements which the torpedo-boat of to day (except speed) does *not* possess, but is seeking; and in this one characteristic, —speed,—the 60-foot submarine-boat can be given a speed that will be adequate to secure her control of all the current or tidal conditions, and, when necessary, to keep up with the cruising speed of a completely equipped squadron.

In comparing the efficiency, however, of the arms of the different classes, we must not lose sight of the conditions by which the United States and Spain were governed in the naval battle off Santiago Harbour. The United States had planned and fought to destroy Spain's best and practically only remaining squadron afloat and did it. Admiral Cervera certainly had had success enough in running away and avoiding the United States naval forces to suggest to him a possibility of escape when he was required by the Madrid and Havana authorities to leave Santiago to go to the defence of Havana,

A TORPEDO GUNBOAT FOR ECUADOR, RIGGED FOR CROSSING THE OCEAN. BUILT BY MESSRS. YARROW & CO., LTD., LONDON.

For ten years, or perhaps more, torpedo-boat builders have been increasing the size and power of their torpedo craft to secure sea-going qualities until more than two thousand tons have been reached and the craft has outgrown its real type, to become a rapid-fire cruising ship, heavily armed with torpedoes. As the size has increased, the boats have become more and more visible; in fact, they are torpedo-boats no longer, except in name. At first, masts and sails were fitted to aid them in crossing the seas, but all this additional equipment simply added to their visibility and decreased their efficiency.

and in carrying out his instructions he appears to have decided upon what has been laid down from Napoleon's time as the best of strategy,—to concentrate all his forces and destroy the flagship *Brooklyn*, which was the weakest of the immediate attacking force, trusting to finally engage her at a speed that would prevent the battleships from helping her, and thus enable some, at least, of his ships to escape. But Admiral Cervera miscalculated not only the steaming qualities of the United States battle-ships, but the splendid accuracy and range of their gun fire, the resistance of their armour and the



THE HOLLAND SUBMARINE TORPEDO-BOAT. PARTIALLY SUBMERGED.

esprit and discipline of their personnel. But as the bottled neck of Santiago Harbour forced his ships to depart therefrom in single-line formation, had each selected her antagonist and attacked viciously with the view of subsequent flight, his individual ships would not have been successively subjected to the heavy fire of several superior ships, and if he really thought his squadron was doomed to destruction, he would, attacking at night, no doubt, in this way, have inflicted greater casualties and more seriously damaged the American fleet, even if he had not succeeded in destroying some parts of it.

Of the many lessons taught, two things were clearly demonstrated by this engagement—the value of battleships, both of high and low freeboard, and the confirmation of the visibility and unprotectibility of torpedo-boat destroyers. When anything happens to the torpedo-boat or destroyer their advocates excuse the results from the point of view of personal errors, and endeavour to show how differently they would have been handled by other officers and crews.

We all know that personal bravery and character, calmness and coolness, have won many battles and will continue to do so; but we must not forget that thousands of torpedo-boats of various tonnages have been built, and yet practically nothing has been accomplished in the two wars in which so much was expected of them. It is, therefore, the more to be regretted that the submarine-boat has not been given an opportunity to show in actual service her ability to give naval warfare the benefit of her submarine control.

The opinion has frequently been put forth that men who go down in submarine-boats are required to take too great risks, and yet in war, cutting-out and bottling-up attempts and reconnoissances, similar to those of the *Winslow* and *Merrimac*, are carried out in the face of almost certain death. Hobson and his crew escaped death, but it certainly was by a miracle, for no less than a dozen weapons of different character were pitted against them. Surely, if complete or semi-submergence can be controlled—and we know they can be—the writer believes that craft capable of such submergence should be used to replace the more dangerous ones.

Harbours must be defended against attack, and can probably be defended most economically by submarine torpedo-boats. As previously stated, the objection may be raised that the only complete defence must comprise elements of competent offence, and that the submarine-boat cannot follow the

enemy's blockading or attacking fleet to sea and destroy it. Neither can these functions be performed by the ordinary type of torpedo-boat or destroyer. The experiences of both recent naval wars have shown that they would be completely destroyed.

If the submarine-boats cannot assume complete offensive operations, they can more surely fill the gap between the immobile defences and the perfectly mobile ones by virtue of their being a mobile-immobile defence (if the writer may be allowed so to describe it), or a moving mine, combining all the terrors and other certainties of the fixed mine and adding to them that of rapidly changing its location and position as circumstances require, the more readily releasing channels and harbours from dangerous conditions when the peaceful use of them is required. And if the offensive characteristic is considered a *sine qua non*, build the boats larger, as semi-submerged boats, if it should be deemed wise to do as has been done with the present torpedo type, requiring them to act on the offensive instead of being restricted for the mosquito purposes for which they were originally intended.

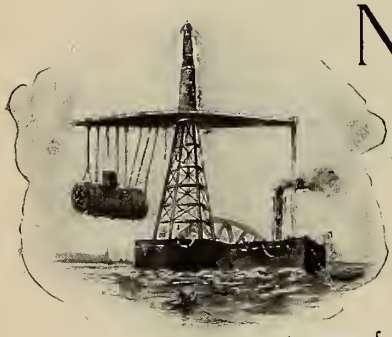
Referring to the "small but active fleet" which Commander Wainwright, of the United States Navy, suggests for protecting the advance basis, what better types could you have than the submarine and semi-submerged? It certainly must be accepted that if Spain had efficient submarine-boats in her Cuban harbours, their blockade by American ships would have entailed serious risk, and the recent blockade would not have been by any means the dull, peaceful life of which many have complained.

No doubt one of the best qualities of a vessel is mobility, and if she is to be visible it is most important; but in considering this element we must carefully separate the class comprising battleships, cruisers, gunboats, monitors and others that are to visibly perform their work and show their greatest power by effective manœuvring and gun practice, and which are protected at very great expense and sacrifice of coal and ammunition supply, from that class which were conceived to approach the enemy stealthily by reason of their smallness and invisibility; a class in which great speed has been sought to aid in their escape after their torpedo work had been accomplished. But what has been the result? To meet the requirements of offence they have increased in size until they are no longer invisible, and, having no protection whatever, have become easy targets for rapid-fire batteries, and that at ranges far beyond the efficiency of the automobile torpedo.

A BRAZILIAN SECOND CLASS SPAR TORPEDO-BOAT. BUILT IN 1883 BY MESSRS. JOHN I. THORNYCROFT & CO., LONDON.

SOME ELECTRICALLY-DRIVEN SHIPYARD TOOLS.

By F. von Kodolitsch.



NOT the least promising field for electric power is, at the present time, to be found in shipyards and boiler and bridge shops, where, often, old types of machine tools and the great amount of hand labour left to be done entail a high rate of working charges.

In such establishments water power for producing the electric current at a low price is very rarely available; but it is possible to produce the necessary current by very economical steam engines and to transmit this latent power to any desired spot in a most economical way. The efficiency of a good generating dynamo in a central station amounts to 95 per cent. of the brake horse-power developed by the steam engine. If the conducting wires are liberally calculated, there cannot be a greater loss by the cables than 5 per cent. The efficiency of a good electric motor is usually about 80 per cent.; and we have, therefore, in the case of electrical transmission in shops, an efficiency of 70 per cent. of the power applied.

In shipyards, for instance, the bigger tools, like rollers, shears, and punching machines, are usually driven by separate small non-condensing steam engines which work at the ends of long steam pipes. In many cases it has been

AN ELECTRIC BORING MACHINE. TYPE NO. I.

SOMETHING SIMILAR, BUT OF HEAVIER DESIGN. TYPE NO. II.

AN ELECTRIC BORING MACHINE, SPECIALLY DESIGNED FOR SHIPBUILDING PURPOSES. TYPE NO. III.

found that 50 and more pounds of steam are required to develop one I. H. P. In a well-designed electric central station the steam engine, which may be triple expansion and condensing, will require about 16 pounds of steam per hour for every indicated horse-power. If we now apply the 30 per cent. losses caused by the previously mentioned electric transmission of power, we find that in any place of the shipyard there may be had one horse power for $16 \times 1.3 = 20.8$ pounds of steam, as against 50 pounds by the old system. What influence this has upon the coal bill does not require emphasising.

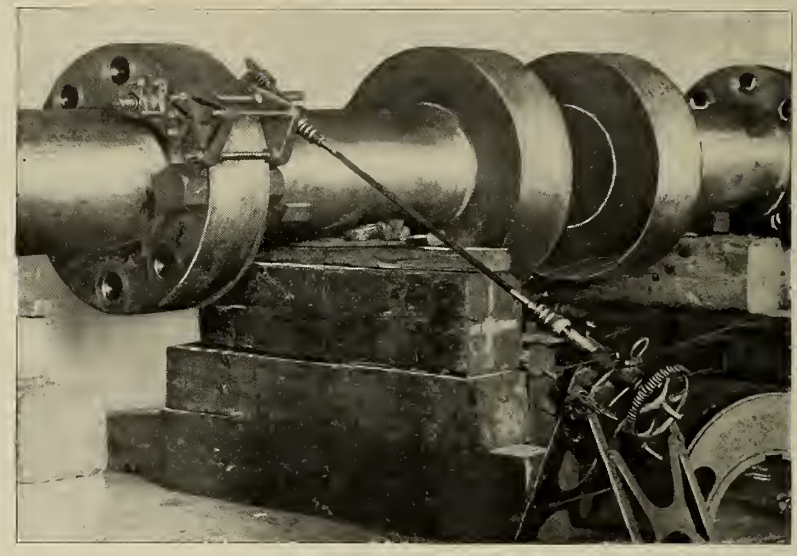
In former years attempts were made, especially in the building of warships, to place on board of the ship in construction steam engines, gas engines,

petroleum motors, air compressors, and hydraulic motors, in order to drive different kinds of machine tools, and thus to save the expense of transporting the material from the tool to the ship, and *vice versa*. All these arrangements will be rapidly superseded by the application of electric transmission of power, as with this it is not necessary to keep one and the same machine tool always in one and the same place. Each machine tool can have its own electric motor and be entirely independent of all shafting and belts. Therefore, every machine tool in a shipyard can be placed at any moment in the most suitable position.

There is, indeed, a general tendency, at present, amongst all tool-makers to reduce their machines in size and weight to a minimum, and to take them to the piece which is to be tooled, and not *vice versa*, as has been the custom hitherto.

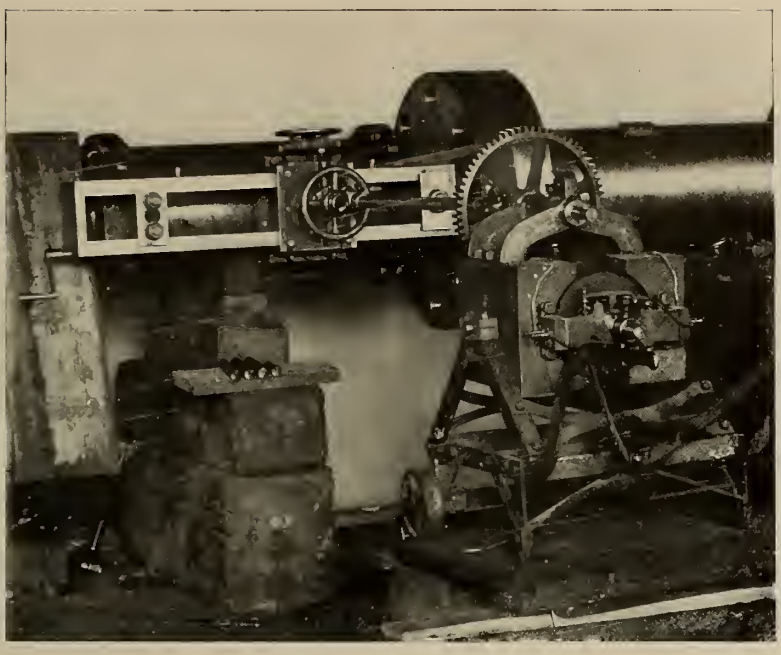
To show the usefulness of light, portable machine tools in marine engineering, the writer would give the following example:—A large marine-engine cylinder, weighing 11 tons, was formerly taken to the cylinder-boring machine, the planer, and to the drilling, tapping, and studding machines. By the application of electricity, the time usually wasted in the operation of drilling, tapping, and studding can be saved, for, while the cylinder is on the boring and planing machine all these processes can be executed simultaneously by a number of small electric boring machines. The writer's experience has taught him that, by this system of working, a steam cylinder of a marine engine of the weight mentioned can be finished about ten days sooner than when the older system was applied.

Electrically-driven tools, in general, must, to be practical, possess three principal features,—portability, lightness, and simplicity. As drilling requires a rotary motion, the present type of electric motor is particularly adapted for this purpose, and, of all electrically-driven tools, the electric boring machine is the most useful and economical.



A BOLT-HOLE REAMING MACHINE.

At present there are probably few machine tool-makers who supply portable electrically-driven tools as required for engineering and ship-building purposes; therefore one is obliged to make such tools in one's own shop, and to buy the motors. When the writer introduced electric transmission of power in the machine shops and shipyard with



CUTTING KEY-WAYS ELECTRICALLY.

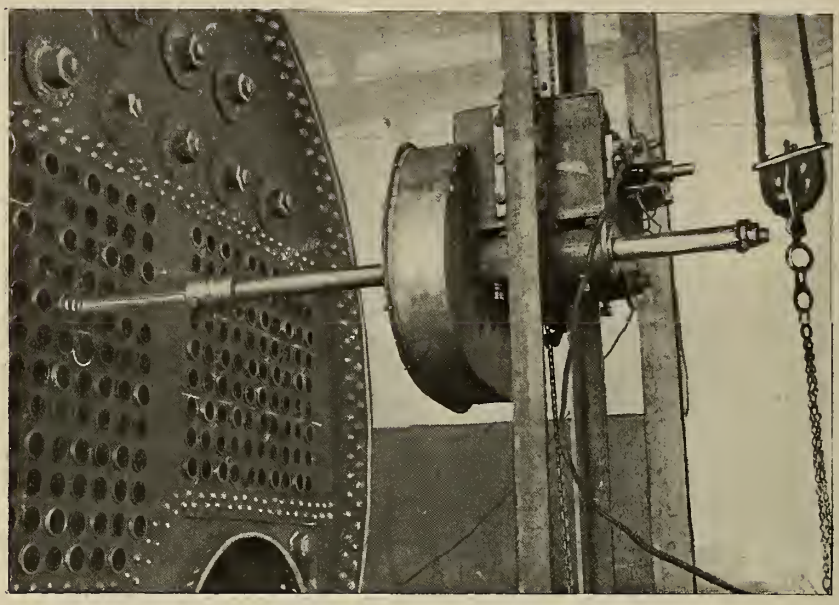
which he is connected,—those of the Austrian Lloyd Steam Navigation Company, at Trieste, Austria,—he developed first the most necessary types of boring machines, of which they are

AN ELECTRIC SHIPYARD PUNCH.

now making six distinctly different classes.

There is Type No. I., weighing 2 cwts., the smallest size with a fast-running drill, for boring holes up to 1 in. diameter. The motor is of 1 H. P. There is a drill press which can be applied in almost any position, and the motor can be used on a two-wheeled car, or placed, without this car, on a small platform. The drill press is separated from the boring machine and driven by a telescope shaft, having two universal joints. There is a special arrangement, made by two guide rods and a sleeve on the telescope shaft, to take up the turning momentum produced by the drill press. The writer purposely abandoned the application of any flexible shafting, as the turning momentum of the drill press cannot be thus counterbalanced, and if this has to be done by the workman, the operation of drilling becomes very fatiguing. Moreover, flexible shafts are very apt to break, and very difficult to repair. The initial cost also is more than that of a telescope shaft. As regards the handiness and easy application, there is no difference between the two systems.

Type II. of the writer's drilling machines is, in general, of the same design



ELECTRIC BOILER TUBE EXPANDING.

AN ELECTRIC STACKING CRANE.

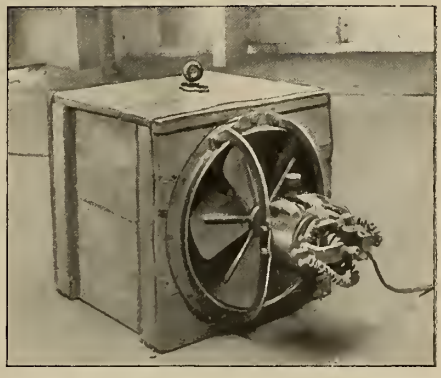
as Type I., but it is heavier and more powerful. The motor is 1½ H. P.; weight, 4 cwts.; size of hole which can be bored, 1½ in.

Type III. was specially constructed for shipbuilding purposes. A 1½ H. P. motor is mounted on a two-wheeled car, and a vertical spindle is driven by two pairs of mitre wheels. The boring spindle is pressed down by a hand wheel. The weight of the boring machine itself and of the workman are sufficient for pressing down the boring spindle, and a great saving of time and weight is obtained as compared with boring machines which are made for holding on with electro-magnets. With this same machine one man can bore four hundred ½-in. holes in ½-in. deck plates in one day. The same machine is also used for countersinking holes on deck. One man can easily countersink in a day from 800 to 1000 holes. In countersinking, the hand wheel for feeding the drill is not touched. After the drill is in position, the man takes the two handles, and, using the apparatus merely as a wheelbarrow, wheels the whole machine from hole to hole; he lifts the countersinking drill out of the finished hole by raising the two handles, thus bringing the drill over the next hole and countersinking it by pressing down the two handles,—a very simple and quick operation.

As we are using in our shipyard about six of these countersinking machines, all our plates for decks are, after being punched, immediately placed, and when all the deck plating is completed, the holes are countersunk by running this machine over each row of rivet holes. The skin plating is countersunk in a similar manner. The plates, after being punched, are laid on the ground under the ship, in position corresponding to the place that they are to occupy. The two-wheeled counter-sinking machine is again run over the rivet holes, and after the plate is countersunk in this way it is immediately slung up into its place. By these means the labour of putting the heavy plate on to the counter-sinking machine and taking it away again is entirely saved. Amongst all portable tools this one proves to be the most useful in shipbuilding.

AN ELECTRIC WINCH.

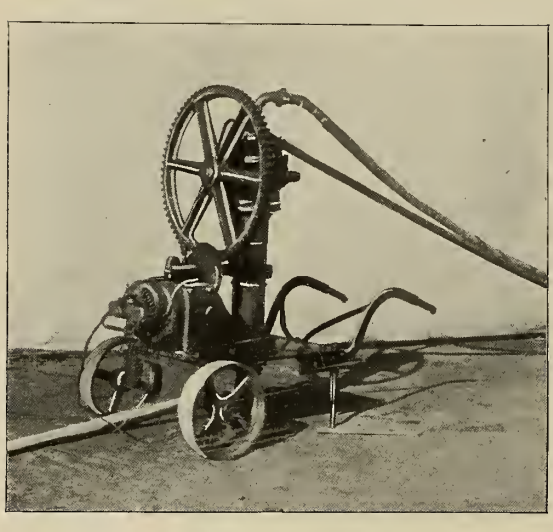
Boring machine Type IV. is the largest size we are making. It has a 3 H. P. motor, weighs about 6 cwts., and can bore holes 3¼ inches in diameter. This machine was specially



AN ELECTRIC FAN FOR VENTILATING THE SPACES BETWEEN SHIPS' DOUBLE BOTTOMS.

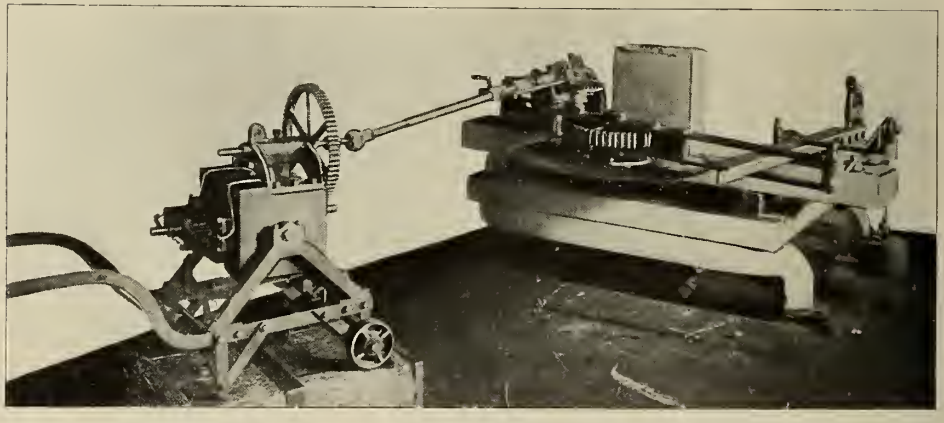
designed for drilling holes in armour plates and armour-plated decks.

Every shipbuilder in building large steamers now uses *Z*-frames, in order to save the expense of riveting on the reverse frame. The weight of such a frame is very great, and many men are required for holding up such a Z-iron when the holes are being punched. For carrying such a Z-iron about, eight, and sometimes ten, men are required. To facilitate and cheapen this operation we now apply a powerful lever punch, which is driven by a telescope shaft and a 1½ H. P. electric motor, placed on a two-wheeled car. This motor is made reversible, so that one can open and close the lever punch by electricity. This operation of punching the large Z-irons is done by only two men. It stands to reason that it requires more time, which in this case is not of so much consequence, but the total expense is reduced by about 15 per cent. This again is a capital illustration of the usefulness of light portable tools.



A PORTABLE ELECTRIC PUMPING OUTFIT.

The sinking of key-ways in large shafting, such as crank shafts, and propeller shafts of marine engines, has always been a very tedious operation, seeing that for sinking the key-way, two holes have to be bored in the shaft with a flat cutting drill, and the remaining piece cut away on the planing machine. This operation necessitates putting the shaft, whatever its weight, under two different machines. Under these conditions it sometimes takes more than a day to finish one key-way. Now, one of the portable milling machines completely finishes the key-ways for fixing eccentric sheaves on a 19 in. crank shaft in the short space of 1½ hour. The dimensions of a key-way so finished recently were 4½ in. length, 2¾ in. width, and ¾ in. depth.



AN ELECTRICALLY-DRIVEN COLD SAW FOR CUTTING OFF RUNNERS FROM CASTINGS.

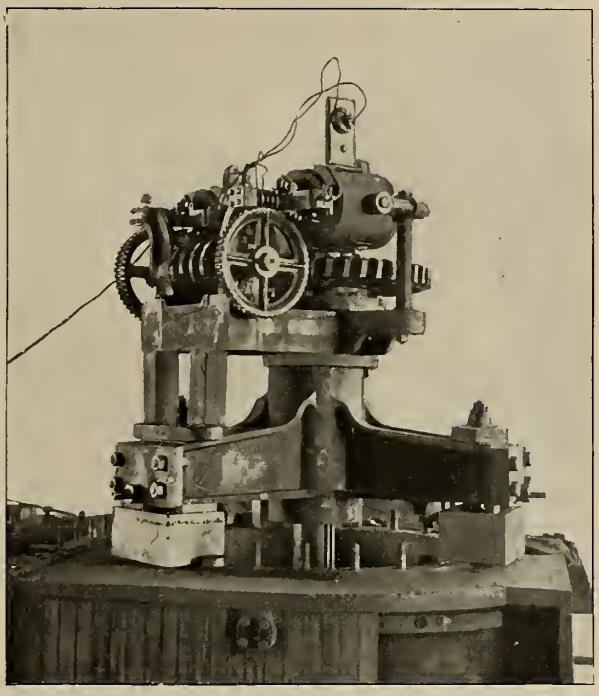
The same machine milled the key-way in a propeller shaft 13¼ inches in diameter in 3½ hours, the key-way in this case being 25 in. long and 3 in. wide. This time included three-quarters of an hour needed for centring the machine, the manual labour employed being only one mechanic and a labourer.

These machines also possess the great advantage of enabling the shipbuilder to mill the key-way on a rudder-head after the latter is in place. This effects a great saving of time and trouble, and ensures the key-way being in its correct position. Many other similar instances of its utility could be cited. By fixing two side brackets this machine may be made stationary and utilised in the shop, the same as any other ordinary milling machine, for milling transmission shafting, winch shafting, and multifarious uses.

It is from the details of work that the savings are made, and every engineer who has had to do with the cutting of key-ways can very easily estimate the time and the labour saved by the adoption of the above machine.

When it becomes necessary to replace old or damaged crank shafts in marine engines, the holes in the coupling are always bored smaller than the diameter of the coupling bolts. The new crank shaft is put in place, accurately levelled, and to make the crank shaft and the adjoining shaft piece a perfect fit the holes must be bored out in position. To do this with ordinary reamers by hand is a tedious and expensive operation, and in order to obviate it we have introduced a small boring spindle, fitted with a universal joint, and capable of drilling conical bolt holes to any diameter or taper. This machine is driven by a small electric motor, and is so arranged that it can also be mounted in the tunnel or engine room of a vessel. Its utility consists in a saving of time and labour, coupled with a perfect and exact execution of work.

With the electric key-way cutting machine, and the electric boring spindle, any crank shaft or tunnel shaft can be completely finished in position without hand labour. These two machines



A CYLINDER-BORING MACHINE.

are the outcome of that necessity which is the mother of invention, and, having for years experienced the need for these machines, we have, since their introduction a few years ago, found them to be of the greatest utility.

After launching a new ship the winch boiler cannot be used at once, and the piping for the donkey boiler, as well as the pump, needs a considerable time before it can be used for draining the bilge water. Similar cases also occur in repairing ships. Rain water accumulates in the bilges, which cannot be pumped out, except by using a hand

pump. In wet weather the constant pumping out of bilges causes a good deal of trouble. To save this the writer introduced a portable electric pump which is lowered into the engine-room or stokehold, electric wires and water hose are connected to it, and all pumping is thus done automatically. For

AN ELECTRIC LIFT ALONGSIDE A SHIP UNDER CONSTRUCTION.

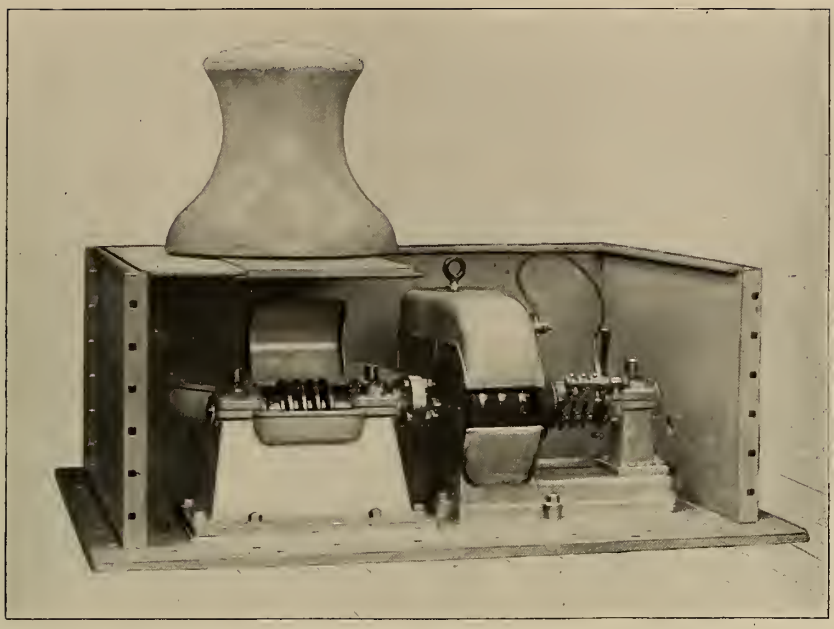
pumping out and cleaning wells this machine has also rendered us much useful service.

Sometimes, when winch boilers are being repaired, the cargo holds have to be cleaned at the same time, and no winches are available for lifting all the rubbish which has to come out. For this purpose we are using an electric winch which is put on to the hatchway and applied in the same manner as an ordinary winch. This apparatus is most serviceable, and is constantly occupied on one or the other of our steamers which are under repair.

It very often happens that a steam cylinder wears oval, or that it takes the shape of a cask, *i. e.*, a larger diameter in the middle than at the two ends. For this defect there is only one remedy, viz., to put in a boring bar and bore out the cylinder. Formerly this was done by the costly process of hand labour, to avoid which the writer constructed an electrically-driven cylinder-boring bar. The lower stuffing box of the cylinder is used as a guide for the lower end. The upper support consists of a boss, having three radial arms, each one having a claw which can be screwed out, and by means of which this star-shaped support can be very easily centred. The boring bar itself is driven by two pairs of worms and worm wheels. The number of revolutions of the boring bar is four or five per minute. The centring of the bar is usually completed in about two hours, while two days is the usual time we require for boring out a steam cylinder by this electrically-driven machine. Only one man is required to supervise the working.

Any one who has had to do with very large steel castings knows what a trouble the cutting-off of the large and numerous runners causes. For instance, on large sternposts there are runners of 12 in. by 6 in. section. To obviate the moving of the whole weight of the post the writer has constructed a portable circular saw which is clamped on to the sternpost to cut off the runners. By using three of such portable circular saws simultaneously on one and the same sternpost the whole operation is very quickly accomplished. The illustration on page 494 shows the construction of this apparatus.

The cleaning out of the double bottoms of ships sometimes becomes a very dangerous work on account of the foul air. I remember two cases where men who went in for repairs were suffocated. If no ventilation is applied to the double



AN ELECTRIC CAPSTAN MADE BY MESSRS. ERNEST SCOTT & MOUNTAIN, LTD., NEWCASTLE-ON-TYNE, ENGLAND.

bottom, life there becomes impossible. Any one who has spent only one hour inside a double bottom will corroborate this statement. Even in a new ship, when the double bottom is to be cemented, the workmen have to be changed every half hour, especially in summer time. To give fresh air to the men we put over the manhole a wooden box, in the lid of which is cut a round hole; into this an air propeller is fitted. This is driven by a small electro-motor of 1-5 H. P., and is quite sufficient for keeping the air in a double bottom always fresh and cool while the men are working there. Great advantages have accrued from the use of this electric fan, the work being done much more quickly and carefully by its aid.

ANOTHER ELECTRIC CAPSTAN MADE BY F. VON KODOLITSCH.

In lagging steam cylinders a very large number of small holes have to be bored into the cylinder casting. This can be very easily and rapidly executed by a small electric motor of about 1-5 H. P., a flexible shaft and a drill press with a breastplate. The pressure which one man can put on the drill is quite sufficient for boring 3-16-in. and ¼-in. holes. The tapping of these little holes is, of course, done entirely by hand.

In finishing up a boiler two columns are placed in front of it, carrying two horizontal rails, between which is mounted a pair of vertical angle-irons. Sliding up and down between these two

angle-irons is a 3 H. P. electric motor, which is counterbalanced by a heavy weight, so that it can be easily moved up and down, and, by the twin motions, can be brought over the centre of each hole which has to be tapped. The armature of the motor drives two pairs of spur wheels in order to get two different speeds, one for screwing in the tap, and the quicker speed for screwing it out again. In this way, one man and one labourer are quite sufficient for attending to this machine. The two tube-plates of the boiler are both tapped at the same time by one long tap. All the stay tubes are also screwed in by this machine.

After the tube-plates are fitted with all the tubes, the same machine is used for expanding tubes by means of applying to the slow shaft either an ordinary Dudgeon tube-expander or one of Yarrow's. To complete the list of portable electric tools, I will also mention an electric riveting machine.

A portable electric side-light cutting machine, which we have in use, is so simple that it requires very little explanation. One of the usual types of side-light cutting machines, which formerly used to be driven by hand, is now driven by a telescope or flexible shaft in connection with a small portable electric motor.

In a shipyard the easy handling of material becomes a very important factor. To reduce labour to a minimum, the writer has constructed a large swivelling crane with an electric motor for lifting and lowering plates. This crane takes the plates from the railway cars and stacks them radially. The same crane is also used for putting the plates on the small handcars for transport to the punching machines.

It is a great convenience in a shipyard to have a large number of electrically-driven capstans, which can be started at any moment by shutting a switch. By means of these same capstans the handcars on which the material is placed are hauled in any desired direction by the distribution of snatch-blocks over the whole area. By means of the same capstans the plates and angles are also lifted into their places. The writer has found an electric capstan one of the most useful applications of electric transmission.

An electric lift completes the electric equipment of our shipyard, and deserves at least passing mention. In our yard there is very little slope, for which reason we are obliged to lay the keels of ships at a great height from the ground. If the moulded depth of a ship is, for instance, 30 feet, the height of the keel towards the forward end of the ship will be about 20 feet; therefore there is a rise of more than 50 feet to the upper deck. A great deal of time is lost by using such a high stairway, and we have, therefore, in our shipyard an electric lift for carrying men and material to the upper deck.

This brief *résumé* of what has been accomplished at the writer's works, affords a few of the many available illustrations of the convenience and economy of electric power, and is suggestive of still further extensions in this field. What shape these should take, an engineer can often best decide for himself, much depending upon special conditions and circumstances.

THE PARIS EXHIBITION OF 1900.

By Frederic Mayer.

THE next great Universal Exhibition will be held in Paris in the spring and summer of the year 1900. Eleven years will then have elapsed since France organised her last World's Fair. Tradition seems to have ordained that, in Paris, a cycle of eleven years shall be the regular interval between two Universal Exhibitions. The Nineteen Hundred, as it is familiarly called, will have a dual importance. Not only will it be more significant and consequential than all other undertakings of its kind, but it will coincide with the close of the nineteenth century, so remarkable from both scientific and economical points of view, and inaugurate an era that promises to be still more wonderful.

France was the first country to organise, in the opening years of the present century, the first national expositions that were ever held. Under such circumstances it seems quite natural that she should claim the honour of bringing the century to a close by an impressive manifestation of peace and work, to which all civilised nations are invited and in which nearly every one has promised to take part.

The way in which the Exhibition of 1900 was brought about may be told in a very few lines. On July 2, 1892, in the Chamber of Deputies, Mr. François Deloncle laid a bill on the table, "praying the government to sign a decree to hold a Universal Exhibition in Paris in the year 1900." The idea was received most favourably in Parliamentary circles, and the French government, acceding to public opinion, and availing itself of its constitutional rights, enacted, on July 13, 1892, that a Universal Exhibition of works of art and of industrial products should be opened on May 5, 1900, and closed on October 31, in the same year; and that the Minister of Commerce and Industry should superintend the execution of the decree. On August 4, 1894, the above dates were respectively changed to April 15 and November 5, 1900.

No time was lost in voting the various supplies for the preparation of plans and other preliminary expenses. But nothing of any importance was accomplished until November, 1892, when the Minister of Commerce and Industry appointed a committee to solve the problem as to where the Exhibition should be held. Nothing could be done until the exact spot had been selected.

Many competent men in different walks of life were asked to appear before this first Exhibition committee. Among the number some were in favour of holding the Exhibition within the limits of the city; others were desirous of seeing it built up beyond the fortifications. Almost every "quarter" of Paris was suggested for some reason or other as the fittest locality for the Exhibition. Sites such as Issy, Saint-Cloud, Point-du-Jour, the Auteuil race-course, the Bois de Boulogne, Saint-Germain, Courbevoie, Saint-Ouen, Saint-Denis, Vincennes, and other suburban places, were named by those who deemed it advantageous to the country to hold the Fair outside of the "Ville Lumière." The Municipal Council of Paris and the Council-General of the Seine Department, however, opposed all motions favouring an exhibition held anywhere outside the city boundaries.

It was hardly surprising to find that those in favour of an exhibition in the interior of the city were almost unani-

mous in their choice; they could imagine no site better suited to the purpose than the 1889 Exhibition grounds, to which it was at first proposed to add the grounds of the Military School, the Palais de l'Industrie, the Place de la Concorde, the garden of the Tuileries, the Champs-Elysées, the Buttes-Chaumont, and even the River Seine, built over in certain parts.

It should not be forgotten that the members of the French Exhibition committee held their meetings during the month of 1893 when the World's Columbian Exposition was in full progress at Chicago The immensity of the American undertaking was not without a certain influence on the ideas of many prominent French exhibition men, who were, at the time, most eager to have in 1900 an exhibition that, as regards size, might well be compared to the Chicago Fair. But the plan of having the Exhibition divided into sections, erected in different parts of the city, failed to please the committee. The main reason given by that body was that the idea of dissemination, if executed, was liable to cause serious embarrassment to visitors and necessitate supplementary outlays for transportation.

In one of the conversations which the writer had, some time back, with M. Alfred Picard, the able Commissioner-General of the Exhibition gave him to understand that he was prepared to reply conclusively to all arguments tending to keep the Exhibition at a certain distance from Paris. He was fully cognisant of the immense difficulties to be vanquished in order to erect the desired buildings without interfering with general circulation and depriving Parisians of many promenades.

"But how would it be possible," he remarked, "to ask the City of Paris to contribute to an undertaking, the first effects of which would be to deprive the municipality of the immense revenues it derives from its *octroi*, or tolls? Why should Parisian exhibitors be asked to transport their goods to some small locality where they would be compelled to put up with great inconvenience and expense? It is plainly evident that if such were to be the case, the Municipality of Paris would withdraw the liberal grant it had promised, and Parisian manufacturers would refuse to exhibit. If an outlay were necessary for a conveyance of any kind in order to reach the Exhibition, a serious drawback would face the Parisian working classes, and the Exhibition, not being within walking distance of the popular quarters, the attendance on week days, and especially at night, would be seriously affected,—so much so that the very success of the whole undertaking would run the risk of being compromised."

In brief, notwithstanding the picturesque situation of many of the suburban sites mentioned, and their adaptability to fine architectural composition, the committee concluded that Paris was the only spot where the Exhibition could be built up and held with every likelihood of success. The vital condition of an enterprise of the kind is to render it of easy access to a very large number of visitors. The primary object of exhibitions is the education of the masses; they are, likewise, great industrial and commercial manifestations. The masses must, in all cases, be enabled to reach them with ease.

The problem of locality having been solved, it was soon found impracticable to build the Exhibition elsewhere than at the Champ-de-Mars, where the three great fairs of 1867, of 1878, and of 1889 were held. The only objection presented was the difficulty which the organisers would encounter in their efforts to present something new on the old spot. What was to become of the Eiffel Tower and of several of the buildings of the 1889 Exhibition? How would sufficient room be found for exhibitors in 1900, when eleven years ago complaints were rife because of the lack of space?

"Beauty shall not give way to immensity," said Mr. Picard, "for too large an exhibition has its drawbacks, and visitors are easily fatigued when they have to roam about and over-exert themselves."

So, after deciding that the old Palace

of Fine Arts, the Central Dome, and the Gallery of Thirty Meters (relics of 1889) should be demolished, M. Picard presented his plans to the Exhibition committee and they were unanimously adopted. These were:—(1) That the Universal Exhibition of 1900 should comprise the Champ-de-Mars, the Trocadéro and adjoining grounds, the Esplanade des Invalides, the Quay de la Conférence, the Palais de l'Industrie and the grounds adjoining this palace, and the Cours-la-Reine and the grounds adjoining it; (2) That a large bridge should be built opposite the Hotel des Invalides and connect the banks of the Seine.

In so vast an undertaking as the Paris Exhibition it was essential, before the first plot of ground was broken, to make a solid financial arrangement which would preclude all possible interruption of the work from lack of funds. The official estimates for the Paris 1900 Exhibition may be explained as follows: —The greater parts of the receipts are assured by the issue of 3,250,000 bond-admission-tickets, of twenty francs each, forming a sum of 65,000,000 francs, from which five millions should be deducted for the expenses connected with the issue, chiefly comprised of a discount to leading French banking establishments which guaranted the sum of 60,000,000 francs. The State agreed to contribute 20,000,000 francs, and the Municipality of Paris promised an identical amount, on condition that the Exposition be held within the city limits, so that here were 100,000,000 francs obtained merely by asking for them.

The State grant to the Exposition is payable in four annuities of 5,000,000 francs each; that of the Municipality in five annuities of 4,000,000 francs each. Slight difficulties arose some months ago about the payment of the annuities, both with the State Department and with the city authorities, but all have now been satisfactorily adjusted, thanks, as far as the Municipal grant is concerned, to the recent bill passed in the Senate approving the plans prepared by the City Department for a Paris metropolitan railroad. The incidental Exhibition receipts from various sources had attained about £75,000 at the close of the year 1897, the sale of old material and buildings bringing in more than half that amount. The total expenditure has been estimated at £4,060,000, divided up as follows:—

General management	£320,000
Working expenses during the exhibition	480,000
Architecture, buildings etc., etc.	2,980,000
Unforeseen	280,000
Total	£4,060,000

This sum does not include the valuable prizes of the lottery, in the trimestrial drawings, in which holders of twenty-franc bond-tickets are entitled to participate. The interest on the sum of £2,400,000 (paid to the Exhibition by the French financial establishments which guaranteed the sale of the bond-admission-tickets) is ample to cover the prize money of the various lottery drawings. The total amount of £2,400,000 was deposited by the Exhibition management as long ago as September, 1896, at the *Caisse des Dépôts et Consignations*. At that time, the general public had subscribed to only 54 per cent. of the total, but it appears now that almost the entire issue is in the hands of the public.

The bond-admission-tickets should not be considered as mere lottery tickets, although, it must be confessed, they bear a striking resemblance to what is generally understood by such. According to the French law, however, they are not lottery tickets, since, in addition to the right they bestow on the holder to participate in certain drawings, they confer other well-defined privileges. Among the latter are principally a reduction of 25 per cent. in the charge of admission to all places of amusement in the Exhibition grounds, and liberal discounts in railway fares to and from Paris during the exhibition months. The bonds, unlike those issued in connection with the 1889 Exhibition, will not be redeemed. Individuals opposed to the idea of holding exhibitions are generally willing to admit that the money expended on universal exhibitions is an eminently productive outlay. It would be difficult,

indeed, to imagine a more profitable investment. A few statistical facts, derived from the financial statements of the Exhibition of 1889 will serve as testimony.

Careful calculations show that the amount of money spent in Paris by visitors from the provinces and from foreign countries during the Centennial fêtes of 1889 amounted to 1250 millions of francs, 500 millions of which came from the pockets of the inhabitants of the French departments, and 750 millions from foreigners. This colossal sum was distributed over the entire country, for Parisians, in order to meet demands in the capital, were compelled to place important orders with the provincial sellers.

The Paris market is but a market of intermediaries, and a large part of the profits it makes is carried at once back to the departments; but, if the quota of French visitors provokes nothing but an interior movement of capital, it is otherwise with the foreign visitors, who undeniably enrich the entire country. One has but to refer to the increase in the French railroad receipts, which, in 1889, amounted to 78 millions of francs, the greater part arising from the fact that foreigners were compelled to travel long distances in order to reach the capital. The increase of seven millions of francs in the receipts of the postal and telegraph departments is likewise characteristic.

An international exhibition in France allows that country to improve her foreign commercial relations. In 1889 the exports were increased by 457 million francs, whilst the total imports reached only 210 millions. The organisers of the Universal Exhibition of 1900 are of the opinion that the coming Exhibition will be more productive than its predecessor, and that foreign visitors will spend a milliard of francs in France.

One of the essential elements in the success of a universal exhibition is the classification of exhibits. Hitherto, managers have been wont to overlook this fact and have remained content to adopt the classification of exhibits in force at some preceding exhibition. But if visitors are to take any interest in the exhibits displayed (it must be confessed that hitherto the general public has preferred the more amusing side of exhibitions to the more serious and instructive features) the manner in which the objects are placed before visitors demands serious revision. In a word, a new classification has become absolutely necessary. In 1900 exhibits are to be presented in a thoroughly logical manner.

"The general classification of exhibits," M. Picard remarked to the writer, "has, in all exhibitions held heretofore, presented most serious anomalies. To quote but one example,—the departments of health and war, that is to say, life and its most cruel adversary, have nearly always been placed in the same group. Now, in 1900, we have arranged matters so as to insure better assorted alliances, and we have placed together products bearing close affinities. We mean to keep pace with industrial evolution. Thus, instead of separating the machinery from the process by which an object is manufactured and from the object itself, we have placed them all together in the same group, and, wherever it was possible, in the same class."

In all sections of the Exhibition the working plant and the process will be placed almost side by side with the products. Machinery will be in motion before the eyes of the public so that visitors may be initiated into the different methods of manufacturers. The public will thus witness the successive transformations of the raw material until the object is manufactured completely. Instructive and attractive lessons will thus be provided.

More importance than at any previous exhibition is to be given to decorative art, in which the French are certainly the most skilled among nations. Two distinct departments are to be set aside for this branch, one for the authors of drawings and designs, the other for manufacturers, so that it will be possible in 1900, for the first time, for an artist to receive an award as an exhibitor in the department of decorative art.

Finally, to the contemporary exhibits, centennial retrospective exhibits are to be added. The latter will be disseminated among the various groups and classes, in order not to escape the attention of the general public. Each centennial retrospective exhibition will form a sort of little museum, showing, in every branch of manufacture, the most notable progress accomplished since the year 1800. M. Picard's new classification has been criticised most favourably by the representatives of foreign powers. In his speech, at the first meeting of the British Royal Commission, held at Marlborough House, on February 17, 1898, His Royal Highness, the Prince of Wales, said, in reference to the classification:—

"The plans and classification which will be laid before you will give the commission some idea of the scope and magnitude of the Exhibition. I will only mention under this head that it will be divided into eighteen groups, comprising one hundred and twenty classes, in which provision will be made for the display of every kind of art, industry, and manufacture. The guiding principle is that similar products, from whatever part of the world they may come, should be shown side by side, and in this respect the Exhibition of 1900 will differ from its predecessors, in which the products of each country have usually been collected together. The arrangement, though less favourable to a striking national display, has many advantages, and admits of a ready comparison of the arts and industries of one country with similar arts and industries of others. No one who reads the official reports can fail to be impressed by the skill with which the classification has been compiled, and by the largeness of conception which marks the organisation of this great enterprise. I will add only that the scheme is being carried out on a scale of magnificence never before approached, even in Paris, and that the Exhibition bids fair to surpass any of its predecessors in extent and splendour."

The eighteen groups to which H. R. H. the Prince of Wales referred are the following:—

I. Education and Instruction; II. Works of Art; III. Appliances and General Processes Relating to Literature, Science and Art; IV. Mechanical Engineering: V. Electricity; VI. Civil Engineering. Transportation; VII. Horticulture and Arboriculture; IX. Forests. Sport. Fishing. Gathering Wild Crops; X. Food Products; XI. Mining. Metallurgy; XII. Decoration and Furniture of Public Buildings and of Dwelling Houses; XIII. Thread. Yarns. Textile Fabrics. Clothing; XIV. Chemical Industries; XV. Various Industries; XVI. Social Economy. Hygiene. Public, Charitable Relief; XVII. Colonisation; XVIII. Army and Navy.

Although placed under the direction of the French Official Department of Commerce and Industry, the sole organiser, the supreme chief and managing director of the Exhibition of 1900, is M. Alfred Picard. His appointment to the post of Commissioner-General dates back as far as 1893, and since that year he has been indefatigable in his work. It may be said without fear of denial that nothing is undertaken at the Exhibition without having first received the sanction of the Commissioner-General, and that when his signature appears at the foot of a document, plan or estimate, his hierarchical chief, the Minister of Commerce and Industry, approves it as a matter of course.

M. Picard's biography is short. He was born at Strasburg in 1844, and entered the Polytechnic School in 1862. From there he went to the French National School of Engineers, finally settling down as an engineer in the city of Metz. He took a very active part in the Franco-Prussian war, fighting, first, with the army of the Loire, then commanding a batallion of engineers at Verdun.

After the terrible years of 1870-'71 he superintended the construction of several railways and canals in the east of France and the erection of some important reservoirs. He joined the Department of Public Works late in the seventies, and was appointed Director of Roads, of Navigation, and of Mines.

In 1881 he became a member of the Council of State, in which body, since 1885, he occupies the high post of President de Section, the special sections over which he presides being those of Public Works, Agriculture, Commerce, and Industry. In engineering circles his works on railways (four volumes) and his history of French railways (six volumes) are classical books.

The appointment of this eminent engineer to the post of Commissioner-General of the Exhibition of 1900 is due, it should be added, in some measure, to his official History of the Paris Exhibition of 1889,—a work in ten volumes, a veritable encyclopedia of art and industry. It is now generally admitted that a more capable man for the position could not have been found, and the French government, Parliament, and the nation, for once agree unanimously that the selection was a most felicitous one. M. Picard has already shown himself capable of solving hundreds of intricate problems that rarely fall to the lot of an engineer.

Although nothing is undertaken without Mr. A. Picard's sanction, yet one would be wrong to think that M. Picard works single-handed. His lieutenants, however, are few in number; but they are extremely active and intelligent. It might be supposed that in an enterprise of the magnitude of the Exhibition of 1900 considerable friction between the leading powers would frequently occur. Such, however, is not the case. The entire machine progresses as quietly and as regularly as a clock; complicated as the works of the instrument may be, they have been set in motion and are under the constant surveillance of a great artist in mechanics. M. Picard's chief officers are:—Director-General Delaunay-Belleville, General Manager of the Foreign Affairs Department of the Exhibition; M. Stéphane Dervillé, General Manager of the French Sections; M. Bouvard, Chief of the Department of Architecture; M. Henri Chardon, Secretary-General of the Exhibition; and M. Albert Legrand, private secretary to the Commissioner-General.

M. Delaunay-Belleville has been president of the Paris Chamber of Commerce four times. Like M. Picard, he is an engineer; he studied at the École Polytechnique and at the Naval School of Engineers. He is the chief of the famous house of Belleville, whose boilers and machinery are so well known in all parts of the world.

M. Stéphane Dervillé, ex-president of the Tribunal of Commerce of Paris, has held several high posts in Paris since 1879, when he was appointed a deputy judge at the Tribunal of Paris. He is a *censeur* of the Bank of France, a member of the board of directors of the Paris-Lyons-Mediterranean Railway Company, and a member of various committees at the Ministry of Public Works. M. Dervillé is also at the head of the firm of Dervillé & Cie, who work twenty-three important marble quarries in France.

M. J. A. Bouvard has been, since 1892, an inspector-general of architecture of the city of Paris. For the past quarter of a century he has taken an active part in all international exhibitions and public fêtes held in Paris. He acquired great fame as the designer of the central dome in the Champ-de-Mars, one of the attractions of the 1889 exhibition. For grandeur of conception and artistic decorative richness, it was a most noteworthy production. In 1900, although his name will not be identified with any particular building, he will be responsible for the general arrangement of all the palaces and gardens of the entire Exhibition, which are being built and arranged under his direction.

M. Henri Chardon, the genial secretary-general of the Exhibition, is M. Picard's most prized lieutenant. On his shoulders fall the somewhat onerous duties of dealing with the press, and it would be difficult to find a more courteous or competent gentleman to fulfil the task. M. Chardon is one of the youngest men on the staff of the Exhibition. He was born in 1861, and, after studying law, became *docteur-en-droit*, and, eventually, an *auditeur* at the Council of State. M. Chardon replaces M. Picard when the latter's duties prevent

him from attending any important ceremony.

Before the Department of Architecture of the Exhibition could be placed in possession of the grounds on which the new palaces are to be erected it was necessary to demolish the greater part of the old Palais de l'Industrie, the Jardin de Paris, the Pavilion of the City of Paris, and various buildings that formed part of the 1889 exhibition. All these structures, with the exception of a small portion of the Palais de l'Industrie, in which the architects' headquarters and a medical post are established, have been torn down, and some of the new buildings are already well under way.

In 1896 it was decided to effect a permanent transformation in the Champs Elysées by building a wide bridge across the Seine, between the bridges of the Concorde and of the Invalides. The new thoroughfare, to be called Pont Alexandre III., the first stone of which was laid by the Czar Nicholas II. during his visit to Paris in October, 1896, will form part of a new avenue (Avenue Nicholas II.), leading from the Hotel des Invalides to the Champs Elysées, on either side of which, in the Champs Elysées, two permanent Palaces of Fine Arts are now in course of erection. These, with the new bridge, will form a most attractive feature of the Exhibition.

Those acquainted with the topography of Paris will easily be able to form an idea of the coming Exhibition. On the Champ de Mars visitors will find the following buildings:—Education and instruction, appliances and general processes relating to literature, science and art; civil engineering and transportation; chemical industries, mining and metallurgy; textile fabrics and clothing; mechanical engineering; agriculture, food products; electricity.

On the Place des Invalides are to be erected the buildings of decoration and furniture of public buildings and of dwelling houses; and of various industries.

In the gardens of the Trocadéro the colonial palaces are to be located.

On the Quay d'Orsay, between the Place des Invalides and the Champ de Mars, will be the pavilions of foreign nations; the building of the Army and Navy; the mercantile marine building; and the forestry, sport and fishing building.

On Cours-la-Reine, between the Alexandre III. bridge and the Place de l'Alma, visitors will find the pavilion of the city of Paris; the horticulture and arboriculture building; and the building of social economy, hygiene, and public charitable relief. And lastly, in the Champs Elysées, will be the two grand permanent fine arts buildings, already mentioned.

The general tone of architecture at the Exhibition, as far as the permanent buildings are concerned, seems to indicate that the monuments will not only be worthy of the city of Paris, but that, in their classical outfit, the two buildings of fine arts will compare favourably with the finest periods of French architecture.

While these two buildings will, when the Exhibition is over, form part of an *ensemble*, comprised principally of the Louvre, the Palais de Gabriel, the Arc de Triomphe and the Invalides, the other numerous buildings are to form but a "passing show," and are but a frame for the six months' fête. Foreign architects and connoisseurs will find many of them of somewhat excessive originality, notwithstanding the fact that many details in the original designs are being simplified in no small degree. Each building will have an architectural character of its own, more or less adapted to the purpose for which the building is designed. They will be elegant and attractive structures, as well-proportioned as the space at the disposal of their designers will permit; and a certain amount of harmony will exist between all of them.

The River Seine will play a greater part in 1900 than during any previous exhibition. For the first time, a Paris exhibition is to be provided with a waterway. The Seine will be a sort of axis of the fair. Gardens and promenades are to be arranged on both banks

of the river, and these decorative embankments, on which a great amount of money is to be expended, will remain as permanent embellishments after the curtain is rung down on the great show.

Foreign nations have responded with unusual alacrity and enthusiasm to the official invitation of the Republic of France to take part in the Exhibition. Of the fifty-six countries invited in the summer of 1898, fifty have sent in a favourable reply. Only two refusals have been received, from Egypt and the Republic of Orange; and it is now certain that these two countries will unofficially make exhibits. Four countries are yet to be heard from,—Brazil, Paraguay, Hawaii and Abyssinia. It may, therefore, be said that all civilised countries will make exhibits, thus enabling the banks of the Seine to become in the spring and summer of 1900 a *résumé* of the intellectual, artistic, scientific, industrial and agricultural efforts of the human race.

Not only have all the countries decided to make noteworthy displays, but the rulers of these countries have taken every opportunity to stimulate interest in the friendly contest that is to close the century in Paris. It is expected that, in 1900, the number of French and foreign exhibitors will reach the formidable figure of 100,000. At previous French international exhibitions the number of exhibitors ran as follows:—In 1855, 10,000; in 1867, 25,000; in 1878, 36,000; in 1889, 62,000.

As was to be expected, almost every country asked for more space than it was possible to allow. Satisfactory arrangements for the allotment to all foreign countries may now practically be said to have been reached. About forty-five per cent. of the entire space available in the official international buildings has been set aside for foreign powers. The following countries will exhibit in these buildings:—Austria, Belgium, Denmark, Germany, Great Britain, Hungary, Italy, Japan, the Netherlands, Norway, Portugal, Russia, Spain, Sweden, Switzerland, and the United States.

Special pavilions will be erected by foreign powers according to the following arrangement:—

On the Quay d'Orsay:—Argentine Republic, Belgium, Bosnia-Herzgovina, Bulgaria, Germany, Great Britain, Greece, Hungary, Italy, Luxemberg, Mexico, Monaco, Norway, Roumania, Servia, Spain, Sweden, Uruguay.

On the Champ de Mars:—Austria, Costa Rica, Dominican Republic, Ecuador, Guatamala, Hayti, San Marino.

In the Champs Elysées:—Russia.

In the gardens of the Trocadéro:—China, Congo Free State, Great Britain (Colonies), Japan, Netherlands (Colonies), Persia, Russia (Siberia and Central Asia), South African Republic, and Spain (Colonies).

It will be observed that Belgium, Germany, Great Britain, Hungary, Italy, Japan, the Netherlands, Norway, Sweden, and Russia exhibit both in the international palaces and in their own special pavilions. These latter buildings will be utilised, in addition to housing certain displays, as exhibition headquarters for the commissioners from foreign countries.

That the foreign participation in the Exhibition is being planned on a very elaborate scale is a foregone conclusion, the best proof being supplied by the fact that enormous sums of money have already been appropriated by foreign governments, most of whom appear to be disposed to considerably increase the substantial grants already made, should events make such a course at all desirable. Great Britain has allowed £75,000, and "this grant," to quote the words of the Prince of Wales, president of the British Royal Commission, and chairman of the Executive and Finance Committees, "I fear will prove insufficient. I trust." His Royal Highness added, "that we may be able to prevail upon the Treasury to considerably augment the grant."

The United States of America have appropriated $650,000, and are inclined to make the amount a round million at no distant date. Germany will spend 5,000,000 marks; Russia 2,000,000 roubles; Bulgaria 300,000 francs; and

the Senate of Finland has voted 100,000 francs for preliminary organisation expenses. Switzerland has allotted 1,650,000 francs; Belgium, 625,000 francs; Roumania, 1,300,000 francs; Norway, 300,000 kronen; and Spain, 40,000 pesetas.

During the period of the Exhibition a series of International Congresses will be held at Paris. These will be under the patronage of the French government, and a special committee has been appointed for each section. No political or religious discussions will be tolerated. The proceedings of all meetings of the Congress will be published, together with the names of all persons taking part in the debates and resolutions.

Since the Eiffel Tower became the great attraction of the Paris Exhibition of 1889, speculation has been rife as to what shall be the corresponding feature of the Exhibition of 1900. As previously stated, the leading attractions of the fair will consist of the two permanent Palaces of Fine Arts in the Champs Elysées and of the Alexander III. bridge across the Seine. The Eiffel Tower, with sundry embellishments, being included in the limits of the Exhibition, will, no doubt, once again prove a "draw"; but as it was the principal feature in 1889, it will not be allowed to enact that rôle again in 1900. A huge revolving wheel, similar to the Ferris wheel of the World's Columbian Exposition, and to the Earl's Court wheel at London, is being built at Paris, outside the grounds of the Exhibition, with which it will have no connection whatsoever. But there will be an amusing side to the Paris Exhibition, for schemes of all kinds have been forwarded in great quantities during the past three years to the Exposition managers.

What shall we see in Paris in 1900? In all probability some of the following attractions:—First, a panorama-diorama, entitled "Le Tour du Monde," by the celebrated marine artist, M. Louis Dumoulin; second, "The History of Costume," by the well-known costumer, M. Felix. Next will come the "Palace of Optics and the Moon at One Meter," thanks to a huge refracting telescope, due to M. Deloncle; "An Aquarium Theatre," by M. Guillaume; and "A Panorama of Sea Voyages in Distant Lands," by M. Hugo d'Alési.

We are to have a grand mining exhibition beneath the Trocadéro Palace; an Indian Village, with numerous pagodas and pretty bayadères; a reproduction of ancient Alexandria; a Kingdom of Siam; a Javanese theatre; and last, but not least, a "Street of Paris," in which MM. Forain, Caran d'Ache, Maurice Donnay and other eminent Montmartre talents are to be allowed full liberty. Here will be established, no doubt, the gayest spot of the Exhibition, and the clever artists and poets who have migrated from the popular Parisian hill to the boulevards will revive, in the interior of the Exhibition, the "Black Cat cabaret," and other resorts famed for wit, song, and good beer. It is impossible at this early stage to write in detail of all these things in preparation for the Exhibition, because most of the authors are liable to make alterations in the plans which they have submitted before the eventful spring of 1900.

From an engineering point of view, perhaps one of the most novel features of the Exhibition will be the movable platform, or railway. A road of this kind existed at the Chicago Exhibition, and also at a more recent exhibition in Berlin. But it seems to be reserved for Paris to put the movable platform to practical use. In 1900 this novel mode of traction is to be introduced in the shape of an elevated railway within the limits of the Exposition. There will be two platforms, one running at a speed of about 2½ miles an hour, the other at a speed of about 5 miles. Visitors will experience no more difficulty, or inconvenience, in stepping from the less speedy platform to the faster one than they will in stepping from the motionless stations on to the slow platform. These stations will, naturally, be placed on the side of the platform that moves at slow speed. It is currently reported

that the inventor of this railroad, M. de Mocomble, will spend 7,000,000 francs in building it. The total length will not exceed about 2½ miles. As the fare charged is to be fixed at half a franc, whatever be the distance covered, in order that there be no loss, it will be necessary that the daily receipts reach 35,000 francs. As the Exhibition is to remain open fourteen hours out of every twenty-four, and the railway is to have a capacity of carrying 60,000 passengers per hour, there is a large margin for profit.

Many other ideas are still under examination by the special committees appointed to report on "attractions." Lack of space has compelled the management to reject a great number of interesting ideas; nevertheless, those accepted are sufficiently picturesque and varied to permit of one saying in all confidence that Parisian gaiety and amusement will not be absent from the exhibition, and that, side by side with the more serious undertaking, some first-class novel entertainments will be provided.

LIGHT RAILWAYS IN GREAT BRITAIN.

By C. E. Spagnoletti, M. Inst. C. E., Past Pres. Inst. E. E.

IN this age of high pressure, time is an important factor, and any rapid and easy means of locomotion that will economise time must necessarily contribute considerably to the advantage and comfort of the community generally. This has been proved to a certain extent, theoretically, by the fact that the careful deliberations of Parliament have resulted in an act being passed authorising, under certain conditions, the construction of light railways.

For the practical success of these undertakings a judicious selection of districts is of very great importance, and every care is necessary to ascertain whether the requirements, at present or in the immediate future, are likely to be sufficient to pay the expenses of such a line. There could be no more damaging result to the introduction and development of such systems than the injudicious selection of unprofitable territory, which would only tend to show the uselessness of such undertakings from the want of traffic or freight to make a success of such a line, and thus the great advantages which might, otherwise, be afforded to other districts would probably be lost.

The Light Railway Act of 1896 was introduced into the House of Commons by the Hon. C. T. Ritchie, president of the Board of Trade, and received the Royal assent on the 14th of August, 1896. It was promoted with the view of assisting agricultural districts by simplifying the methods of procedure for obtaining the necessary powers for the construction of light railways and avoiding many of the very heavy Parliamentary expenses, and removing or lightening many of the restrictions and requirements hitherto in operation. This act also gives the Lords Commissioners of the Treasury power, under certain conditions, to advance money for the construction of the railway.

That the facilities granted under the act are appreciable is sufficiently evidenced by the large number of applications for powers of construction, which have already been made, though but a comparatively short time has elapsed since the passing of the act. The number of applications has been as follows:—

In December, 1896, twenty-eight applications, representing 308 miles of railway, were lodged with the British Board of Trade. Fifteen of these were for England, ten for Scotland, and three for Wales. In May, 1897, twenty-eight applications were made, the motive

power proposed being as follows:—Electricity, 7; electricity or other motive power, 3; and steam, 18. The first ten represent about 72 miles of railway, and the steam railways about 204 miles, making a total of 276 miles.

In November, 1897, thirty applications were made, the motive power proposed being as follows:—Electricity, 16, representing about 125 miles; steam, 13; and hydraulic (incline), 1.

Some of the applications ought to have been made under the Tramways Act, and were, doubtless, due to the anxiety of tramway companies to evade some of their responsibilities by applying for powers under the Light Railway Act instead of under the other. This may possibly also explain the refusal of the Light Railway Commissioners to pass several of the schemes, though the number of refusals has not been large.

During 1897 twenty-five schemes were considered by the commissioners with the following results:—

Motive Power.	No. of Schemes Considered.	Result.
Steam or other Motive Power.	1	Withdrawn.
Electricity	15	6 Passed. 1 Passed with modifications. 1 Postponed. 4 Withdrawn. 3 Refused.
Electricity or other Motive Power.	9	2 Passed. 2 Passsd with modifications. 2 Withdrawn. 3 Refused.

The first or "record" grant made under the act by the Lords Commissioners of the Treasury was in December, 1897, to the promoters of the Tanat Valley Railway (Wales) to the extent of £18,000, and though a number of schemes had been considered up to that date, this was the first one in which an advance had been made.

In the construction of light railways the difficulty is to strike the happy medium. British railway engineers are naturally inclined towards the solidity of an ordinary trunk line, which means in most cases more expense than a light railway can bear. On the other hand, care must be taken not to construct works too flimsy and meagre in character.

A careful estimate should be made of the requirements of the district and full allowance made for the future development of traffic, and it will be found to be ultimately much cheaper to fully cater for these possible requirements at the outset than to make too small a provision at the beginning and be continually making additions at enhanced expense as the traffic grows, and when land has increased in value.

The permanent way and structures, therefore, should be sufficiently solid and substantial to stand the heaviest traffic which is likely to be placed upon it, and sufficient stations, sidings, crossover roads, goods sheds and engine sheds should be provided to give every facility for the encouragement of traffic and to secure a monopoly in the district.

In some places a track may run alongside a public road, in which case a continuous barrier may be necessary; but it may be better in many cases to make a new road for the railway, as many public roads are quite unsuitable for this purpose, being sometimes merely developments of pathways, and more or less winding and undulating. A more direct and level route could probably be taken with little additional trouble and without any considerable increase in the outlay.

It will be most desirable to make the gauge the standard one of the country in which the railway is to be run, as although a narrow-gauge line, say, three feet, could be built for perhaps 35 per cent. less than a 4-foot 8½-inch line, the avoidance of the delays and extra labour and plant involved in transfer of goods, and the ability to intercommunicate with the surrounding standard gauge lines, would, in the long run, more than compensate for the increased initial cost. On the Festiniog line the cost of transfer is from ¾d. to 6d. per ton, according to the class of goods dealt with, and the cost on an average line may, perhaps, be taken at from 3d. to 5d. per ton, — a very considerable amount compared with the cost of haulage.

Where the speed will not exceed 25

miles an hour, and, especially, where the line is to be worked by only one locomotive, the railway company may dispense with many of the ordinary requirements, such as gate watchmen, signals and telegraph, and fencing need be erected only at dangerous places, and thus a considerable saving in the outlay may be made.

Where the speed is to be 25 miles an hour, and the locomotive weighs about 30 tons, 45-pound rails would be found sufficient, with sleepers measuring, say, $6' \times 7\frac{1}{2}'' \times 4\frac{1}{2}''$, fixed about 1900 to the mile, and the ballast under the sleepers 4". Where the maximum rate of speed is to be lower than 25 miles an hour, the rolling stock and permanent way may be somewhat lighter. In practice, it has been found that 15 miles an hour is the maximum speed consistent with cheap maintenance on light lines.

The working expenses and earnings of the Corris, Easingwold and Glyn Valley Light railways are stated to be as follows:—

Corris worked at 2s., 2d. per train mile. Earning 3s., 2d per train mile.
Easingwold worked at 1s., 10d. per train mile. Earning 2s., 1d. per train mile.
Glyn Valley worked at 1s., 7d. per train mile. Earning 2s., 9d. per train mile.

In thinly populated agricultural districts, the average light railway would not be likely to earn more than £5 per mile per week, and the normal working expenses would vary from 50 to 60 per cent., of which one-fourth would be absorbed by coal, renewal of rails, and repairs to locomotives.

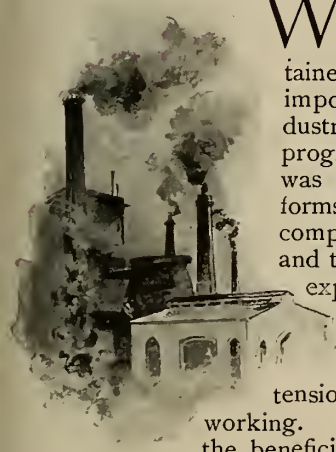
Though the earnings may be small, there is little doubt that light railways will, where worked economically, pay a fair dividend, and by acting as feeders to the trunk lines will tend to increase the dividends of the latter also.

Judging by the large number of applications for powers of construction, it is evidently believed that light railways will be of great practical utility to the travelling public, and still more so to the agricultural interest for which they were designed. Considering the chronic depression of agriculture in Great Britain for years past, it is to be hoped that the Light Railway Act will fulfil its object and give the needful encouragement to the British farmer, for the necessity for encouraging the home-growth of wheat and other food stuffs is more apparent than usual at the present time.

If a war between two nations, in which we are not interested, will cause a rapid rise in the price of wheat in a few days, it is easy to contemplate what would be the result of a long-continued war, in which we might be engaged as principals with one or two of the great powers. If the Light Railway Act does nothing else than encourage the production of home-grown wheat and thus make us less dependent upon the foreign supply, it will not have been in vain.

BLAST-FURNACE GAS AS A MOTIVE POWER.

By H. Savage, A. M. Inst. C. E., Engineer of the Société John Cockerill, Seraing, Belgium.



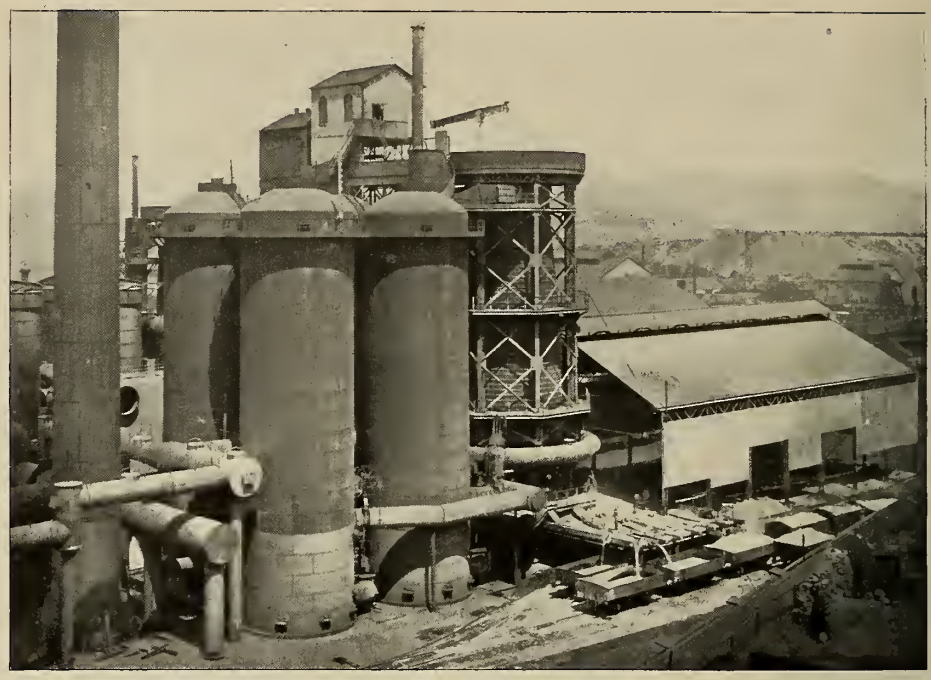
WITHIN recent years the gas engine has attained a position of high importance amongst industrial motors. Its progress for many years was slow; in its early forms the engine was complicated and costly, and the exclusive use of expensive lighting gas as a source of motive power deprived it of all pretensions to economic working. The discovery of the beneficial results of compression of the gas, and the general introduction of the Beau de Rochas cycle were the first great forward steps in its career.

The engine became practical; it was convenient, could be started or stopped at a moment's notice; it required no boiler, no stoking, no coal store; it could be placed anywhere, offered no danger to surroundings, and the nuisances due to chimneys, smoke, dust, and ashes were suppressed. For small powers it obtained a well-deserved popularity. But for large engines its deficiency as an economic motor still kept it in the background. Producer-gas gave it a further advancement; the work of Dowson, Mond and others brought it more into the field as a large motor, and several years ago the announcement was made, and proved, that steam had at last found a competitor to threaten its supremacy as a source of motive power.

In 1879 the late Sir W. Siemens stated, before a committee of the British House of Commons, that from fourteen to fifteen times as much light could be obtained by utilising a given quantity of ordinary coal gas as fuel in a gas engine, coupled to a dynamo, as by the direct use as an illuminant of the same quantity of gas. Mr. Dowson, in a paper read before the Institution of Civil Engineers in 1893, gave it as his opinion that the ratio might then have been taken as twenty to one. More improved gas engines, and of much larger dimensions than any existing at either of the above-mentioned times, have, of late, been made, and of these it is no exaggeration to say that they surpass in economy of working all save the most perfect of multiple-expansion steam engines, under the supposition that these last are worked with the utmost care and attention.

Producer-gas had rendered the large-sized gas engine an economical possibility. Engines of from 100 to 150 effective horse-power made their appearance, and workshops, pumping and lighting stations and other establishments adopted the new motor. The gas producer took the place of the boiler in most of these plants, and various forms were introduced, utilising natural or forced draught, steam-jet injection and many other devices. As time went on, the idea presented itself to some daring minds that, for years past, iron manufacturers had possessed an apparatus which was in itself the greatest and most economical of all gas generators, the product of which had so far, to a large extent, been wasted through crude and unscientific methods of employment.

Each ton of pig-iron, run from the hearth of a blast-furnace, is accompanied by the evolution, from the furnace top, of from 150,000 to 180,000 cubic feet



ONE OF THE BLAST FURNACES AT SERAING, SUPPLYING GAS FOR GAS ENGINE USE.

of combustible gas. It was long disputed that this gas, the combustion of which in an ordinary boiler flue was sometimes a matter of difficulty, possessed sufficient heat-producing capabilities to allow of its use as a motive agent. Another insuperable objection to the employment of blast-furnace gas in the cylinder of a motor engine was supposed to lie in the difficulty of ridding it sufficiently of dust. Both these objections have, however, been set at rest.

Combustion is known now to be largely a function of pressure as well as of temperature and chemical combination. Gaseous mixtures, completely inert in the presence of flame under ordinary atmospheric pressure, burn violently, or even explode, if that pressure be doubled, trebled or raised to a still higher degree. The heavier dust particles can be separated by washing, and still better by depositing in large chambers, where the gas partially loses its velocity and power of holding solid matter in suspension.

We thus have in every large modern ironworks an almost unlimited source of power, the means of utilising which have been placed at our disposal, thanks to the progress accomplished in the construction of gas engines of large size and efficient type. The final result is nothing short of an industrial revolution. The gas-fired boiler, the recognised mainstay of all iron mills or smelting works, is threatened with extinction.

Not many years ago a well-known authority called attention to the fact that the average consumption of coal per indicated horse-power in a large number of establishments reached 18 pounds per hour. There is no doubt that the ordinary method of raising steam by means of waste gases is in many cases extremely wasteful. Pipes and flues fill rapidly with dust, often an almost perfect non-conductor of heat; cleanings are few and far between; incrustation in boilers further reduces evaporative efficiency, or it may be that corrosive waters have so far weakened the boilers as to oblige the owners to resort to lower pressures, with the con-

sequence that high-class engines no longer give the designed economic results. Condensation, too, does its work in the long pipes conveying the steam to engines at a distance. Let us add that cheapness has often been the main consideration with the iron-master who decided to adopt the not universally followed practice of utilising waste gases, and that the boilers of iron and steel works frequently belong to the most primitive type. That such boilers should hourly consume from 600 to 700 cubic feet of gas per indicated horse-power, extravagant as such a consumption may appear, is by no means surprising, and although no doubt incomparably better results may be obtained in carefully managed modern plants, still the objections of the great first cost, space occupied, inconvenience of renewal and attentive supervision required may well cause manufacturers to welcome any simpler method which might enable them to utilise the superabundant thermic energy of their furnaces.

In these days of progress a want felt and acknowledged has rarely to wait long before being satisfied, and in the present case, while blast-furnace managers, on one hand, were seeking a better utilisation of their gas, gas engine builders, on the other hand, had been long striving to obtain for the continually larger sizes of motor coming into use cheaper and more abundant supplies of gas. The motor and motive power existed; to combine the two was in some degree a natural result, and it is not surprising that in Great Britain, France, Germany and Belgium almost simultaneous attempts were made to carry out this new programme.

At Seraing, Wishaw, Hoerde, and Differdange, and possibly in other places, long and carefully conducted trials were made. The Seraing results, as detailed in a paper lately read before the Iron and Steel Institute by Monsieur A. Greiner, Director-General of the Société Cockerill, at Seraing, seem to show that as much as 20 I. H. P. may be reckoned upon per ton of coke fed daily into the blast-furnaces, and though this result has appeared high, enough has been done to prove that there is in the blast-furnace, considered as a gas-producer, a great reserve of motive power, which, until now, has not been drawn upon to anything like the full extent possible.

The question is now in what manner this fund of motive power shall be utilised which has so long been at our disposal, like many others in times past, neglected, if not ignored. Of course, the ever-increasing requirements of modern industry will supply us in each individual case with a hundred ready answers. The half-dozen blast-furnaces of a works like those of the Société Cockerill at Seraing, affording from 12,000 to 14,000 I. H. P., require from 2000 to 2500 I. H. P. to drive their different blowing engines, hoists, pumps, and other machinery. From 10,000 to 12,000 horse-power,—a force sufficient to operate the different mills, forges, tools and workshop appliances which complete the paraphernalia of a large modern ironworks,—remain at the disposal of the owner.

Electric transmission provides a most convenient means of distributing power at comparatively small expense (compared with the erection and working of separate engines and boilers), to all the appliances which compose a large works, besides, at the same time, providing for light and transportation requirements. Here we find ourselves in presence of a new industrial transformation! The blast-furnace, devised originally for the production of raw iron, and for centuries used solely for that purpose, assumes a new character and appears as a general source of mechanical power.

Transformations of similar kind have already influenced different industries, and seem destined in many cases to affect even their geographical situation. Whereas, formerly, the prosperity of any manufacture was deemed to be closely dependent on the proximity to the factory or works of abundant natural supplies of raw material, modern facilities of transportation and the newly developed usages, discovered day by day, for waste or subsidiary products, seem in many cases to point more to

the neighbourhood of a market for such subsidiaries as a determining factor in the choice of a situation for new establishments.

Already we find in certain parts of Germany, for instance, the utilisation of basic open-hearth slag for agricultural purposes bringing about the creation of steelworks in districts where their existence would hardly have been dreamt of a few years ago. Thus the manufacturers of steel and of artificial fertilisers seem destined to become concomitant industries. The same interdependence is found between recuperative coke-ovens and chemical works, an abundant supply of ammoniacal waters being with these last a *sine qua non*.

Perhaps the most patent example of the enormous value which may be attained by bye-products is that afforded by the ordinary town gas works, which for many years has supplied us with such widely varying commodities as dyes, coke, creosote, light oils and tar, and, within recent years, with motive power, to such an extent that even the supercession of the old gas by the modern electric light scarcely seems to threaten its existence, or even to lower its character as a well-paying investment.

When something approaching to an entire utilisation of the blast-furnace with its enormous output of bye-products in the shape of slag and gas has been realised,—the slag supplying building materials, cement, bricks, pavements, tiles; the gas utilised as we have seen, —then we may possibly expect to see pig-iron manufacture flourishing in many situations where a large demand for iron, for motive power, and for building materials may exist,—say, in the vicinity of all large and progressive cities, although far removed, perhaps, from any natural deposit of ore or combustible. That there is nothing far-fetched or extravagant in such a view is proved by the actual existence of blast-furnaces at such places as Stettin, Germany, and Trieste, Austria, and at certain points on the south coast of France.

Leaving these regions of speculative suggestion, let us return to what has been really done! The highly interesting trials, lasting over two years, conducted at the Seraing works by two young engineers, Messrs. Bailly and Kraft have given results which seem to justify many of the expectations put forward above. The first machine experimented with was a small 8 horse-power "Simplex" gas engine of the type patented by Messrs. Delamarre-Debouteville. This engine ran for a period of eighteen months, but developed only 4 effective horse-power. Later on, after modification of a few details, the full 8 H. P. were attained.

The gas consumption was certainly high, but with the engines working at full load, there is no doubt it could be materially reduced, and it is confidently expected that a consumption of 3 cubic metres (105 cubic feet) per hour per indicated horse-power will not be exceeded in the large 200 horse-power engine recently started. The consumption of gas in the case of the existing boilers and engines is, as we have already stated, somewhere between 600 and 700 cubic feet per hour per indicated horse-power. Thus the experience acquired even with a small motor allows the prediction of a far higher economic result than that obtained by the existing means.

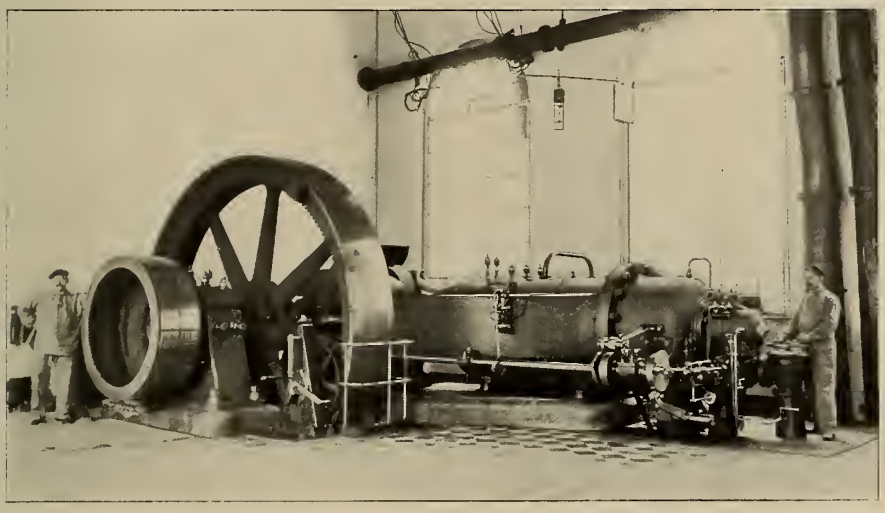
The above results encouraged the Cockerill Company to attempt greater things. A 200 horse-power engine was designed by Monsieur Delamarre and constructed in the company's shops. The supply of gas for this engine is taken from the blast-furnace mains and led through three pairs of coke scrubbers, in which it is thoroughly washed by being brought into contact with water driven into the scrubbers in the form of spray by Körting injectors. After washing, the gas may be sent direct to the engine, although a gasometer exists to serve the purposes of a regulator and reservoir.

The engine has one working cylinder, 800 millimetres (31 1-12 inches) in diameter, with a stroke of one metre (39.37 inches). It is of the usual four-stroke, or Beau de Rochas, cycle type,

each explosion corresponding to two forward and two backward strokes of the piston. The working speed is 100 revolutions per minute, and to insure regularity the engine is fitted with a heavy fly-wheel, weighing about fifteen tons, and a counterbalanced crank, besides which a pendulum governor, acting on the gas inlet valve, restrains any tendency towards excessive speed. The initial compression in the cylinder reaches a pressure of 8 atmospheres, or about 115 pounds per square inch. The gas is ignited electrically. Trials of this engine, conducted by the well-known expert, M. Aime Witz, have given the most satisfactory results. During a continuous run of 24 hours an almost constant power of 180 I. H. P. was maintained, on a remarkably low consumption of gas, equivalent to about 115 cubic feet per hour and indicated horse power. The conditions of the trial were those of ordinary work, no attempt being made to drive the engine to the extreme limit of its power.

The long experience with the steam engine, and the immense amount of inventive talent and mechanical ingenuity which have been devoted to the gradual improvement of its multifarious forms, have given it an extraordinary degree of handiness. The ease with which it can change speed, stop, start, reverse, at the will of the operator, make it a most obedient servant in such operations as rolling, hoisting and other work of an intermittent nature. It must not be forgotten, however, that much of this ease of manipulation is obtained at the expense of economy in the development of motive power.

Electric transmission, while offering equal facilities with regard to the working of different appliances, is free from most of the causes of loss of power which affect steam when distributed over many different points, as in a large establishment.



THE SIMPLEX GAS ENGINE USED IN THE SERAING EXPERIMENTS.

Gas, being the most economic means of producing motive power, here asserts its superiority. A new 200 horse-power engine at present building at Seraing is to be adapted to electric driving. The present one, however, drives an air-compressor, the air from which will take the place of steam in a number of pumps and other machines, a simple cock enabling either steam or compressed air to be admitted at pleasure to the cylinders. At the same time the question of the direct use of gas engines for the working of machinery of different kinds is contemplated as well as the in-

stallation of a blowing-engine in which gas will be the direct motive agency.

The objection based on the presence of dust in the gas was one to which Mr. Lürmann gave great prominence at a recent meeting of German iron and steel makers at Düsseldorf, and one which is by no means minimised by the nature of the gas given off by the Seraing furnaces, in which purple ore is very largely used. It was found, however, that the small 8 horse-power engine was able to run for four months continuously without cleaning, and the new large engines are supplied with far better means of getting rid of the dust. Gas absolutely free from dust is, in fact, no more a necessity with gas engines than distilled water is in the case of steam engines. No inconvenience was experienced from corrosion of internal parts.

Finally, the irregularity in the composition of the gas which was expected to be the great drawback, loses much of its apparent gravity in the light of practical experiment. Gas so poor in combustible ingredients as to be practically useless for heating boilers still gives fairly satisfactory results with the new motor, which seems to adapt itself readily to considerable differences in the quality of its fuel.

The results obtained at Seraing seem to be fully confirmed by experiments made elsewhere, amongst which may be mentioned those carried out at Wishaw, in Great Britain, in which the gas from furnaces burning raw coal are utilised for driving an electric lighting plant, after separation of the tar and ammoniacal waters which they contain. Mr. B. H. Thwaite, the designer of the plant employed, has been equally successful in dealing with the gases from blast-furnaces using coke.

From the foregoing it will be seen that the problem of the direct use in a motor of blast-furnace gas may be considered as successfully solved. Larger powers than any which have been hith erto developed by gas engines may, of course, be required before the full importance of the innovation can be considered as completely established. But progress in that direction is being made. The Westinghouse Company, in the United States, have had on trial for some time past a gas engine working up to 750 I. H. P., and one of 1000 horse-power has been spoken of.

Whether such powers and the still higher ones, which will, no doubt, gradually come into use, will be best supplied by large single engines or by the combination of a number of moderate-powered units; whether the power thus developed will be best distributed from a central station by electric transmission, or carried direct to different motors by means of pipes,—these and many other questions must be left to the future to decide. For the present, engineers may congratulate themselves on the discovery of a new source of motive power and the opening up to their activity of a new field of mechanical developments.

SOME AMERICAN CYLINDER-BORING MACHINES.

By Henry B. Binsse.

THERE is a rule which is the basis of the successful design of every machine tool, and which may be expressed broadly by the statement that the piece to be operated upon must be held so that it cannot yield under the pressure of the cut, while, in turn, the cutting tool must be so supported as to be absolutely rigid. This is the ideal condition, which can never be quite reached in practice; but in the measure that we accomplish our purpose and draw near to it, will the efficiency of the tool increase; and in speaking of the efficiency of the tool it should be understood that this is intended to denote not only the amount of material or stock removed by the cut, or the quantity of the product, but also its quality,—the accuracy and finish of the work.

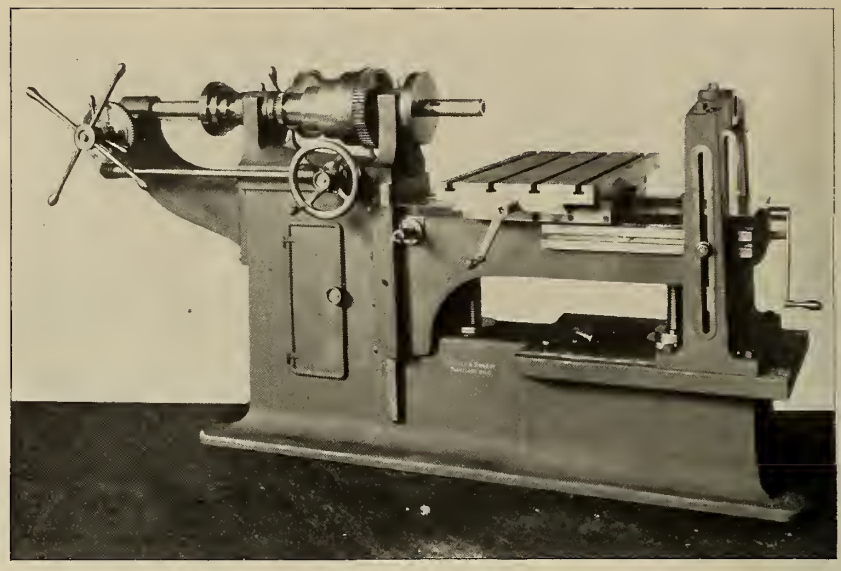
The truth of this proposition may be perceived in the details of the many, widely differing, kinds of lathes. In its essential elements the heavy forge lathe is like to the little foot-power lathe, although the former is capable of paring off a steel chip an inch and a half wide by one-eighth thick, while the other can barely turn down a two-inch diameter shaft. The great lathe, however, is not simply a little lathe magnified a number of times. This would not bring about the desired result. New forms of details are required by the increased power, and they all lead to the same end,—rigidity in the work and in the tool. The proposition becomes self-evident in the so-called turret-lathe box tool.

The possible reduction of a little shaft turned between centres is very trifling; but hold that shaft in a device so that it cannot escape the deep cutting tool and the amount of reduction is limited by nothing but the cohesive strength of the metal.

While it is no great task to devise a firm tool support for the usual cases of turning outer surfaces, a little reflection will make it evident that it is a very different matter with inside turning or boring. The most obvious disadvantage is the overhang of the cutting tool, that is, the lever arm from the cutting point to the point of support, which increases with the cylinder length and renders the operation both slow and inaccurate. Indeed, it was a long time before cylinder boring made any progress. We are told that in the infancy of the steam engine boring was not even attempted. The cylinder of the first steam engine erected in the United States,—and it was an example of the best practice of the day,—was not bored at all, but was used as it came from the sand, the joint between piston and cylinder being made by hemp packing and water.

It might be supposed that it would have been both natural and easy to apply to cylinders the methods for gun boring, which had reached a high point of development at that time; but this was impracticable on account of the great expense which would attend the making of such tools to cover the wide range of diameters required by engineering practice.

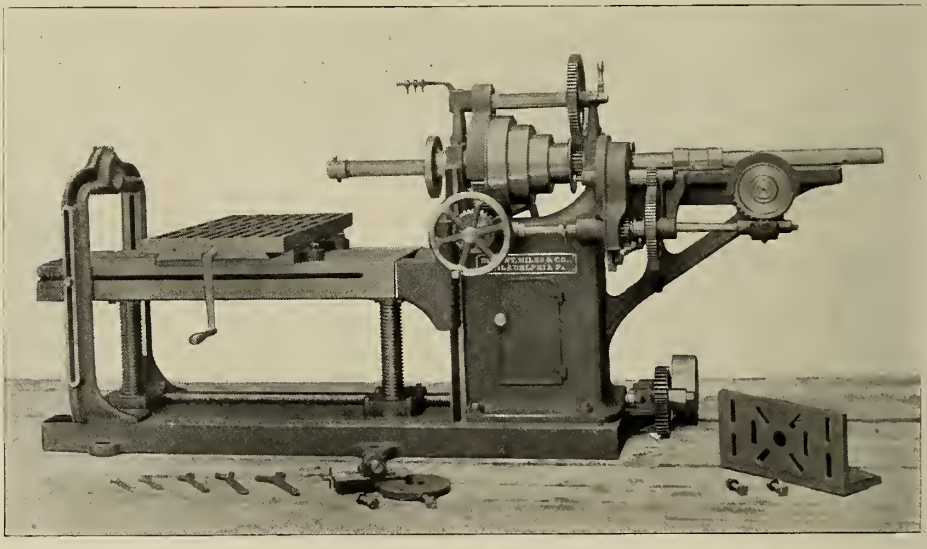
Cylinder-boring machinery remained in a very imperfect condition until the practical application of electricity to lighting and other purposes created a wide demand for high-speed engines and for engines of large power and great economy. In addition, came the in-



HORIZONTAL BORING AND DRILLING MACHINE BUILT BY MESSRS. WARNER & SWASEY, CLEVELAND, OHIO.

vention and growth of air compressors and brakes, ice machines, gas engines, pumps, as well as a general advance towards the manufacture, in place of the construction, of all kinds of machinery.

Up to this period, it was usual to bore large cylinders by using a heavy boring bar, generally of cast iron, upon which slid a piston-like boring head which carried the cutting tools. As the cylinder was bored in a vertical position, there was no sag in the boring bar. This arrangement was put usually in a corner of the workshop, using the



BORING MACHINE BUILT BY MESSRS. BEMENT, MILES & CO., PHILADELPHIA.

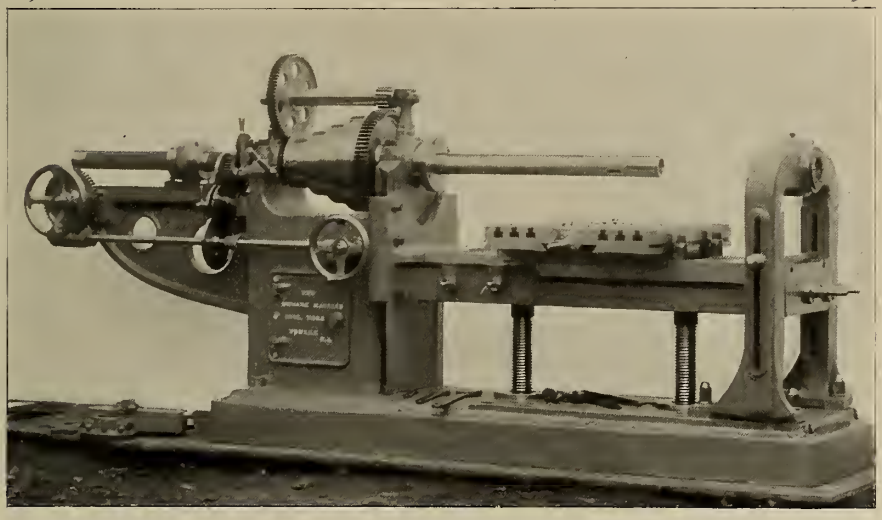
walls to absorb the stresses. Sometimes the apparatus was portable and the cylinder was bored out-of-doors, the power being furnished by a patient horse or by a gang of labourers, less patient. In this contrivance are the elements of the impressive, colossal boring machine built by William Sellers & Co., Incorp., of Philadelphia, shown on page 525, to which further reference will be made.

Small cylinders were finished in a tool of the lathe type, the cylinder being bolted to the lathe carriage, and the boring bar held between the lathe centres. This method was very time-wasting. There was no suitable provision for setting the work, which had to be blocked or wedged up. The boring bar had to be more than twice the length of the work, and it was very difficult to handle. Moreover, the bar was in the way when it was desired to take measurements. These were the chief drawbacks to the lathe as a cylinder-boring tool which led to the invention of the so-called horizontal boring machine, the most useful of all the boring machines of to-day.

The development of this tool from its earliest crude forms has been of such great importance to mechanical industry that it should be stated that the credit for it is generally conceded to William Bement, of Philadelphia. Several machines of this kind from the shops of different makers are shown on this page and the one opposite.

These machines have essential features in common, although the details of each are original.

The work table has three motions,—one vertically, by the movement of the long table upon which it rests, and two in a horizontal plane. When the vertical adjustment has been found, the work table, or carriage, as the writer prefers to call it for simplicity's sake, can be moved either lengthwise or across. With these three adjustments the cylinder can be set in a fraction of the time spent in setting on the lathe type of machine. No blocking of any kind is required.

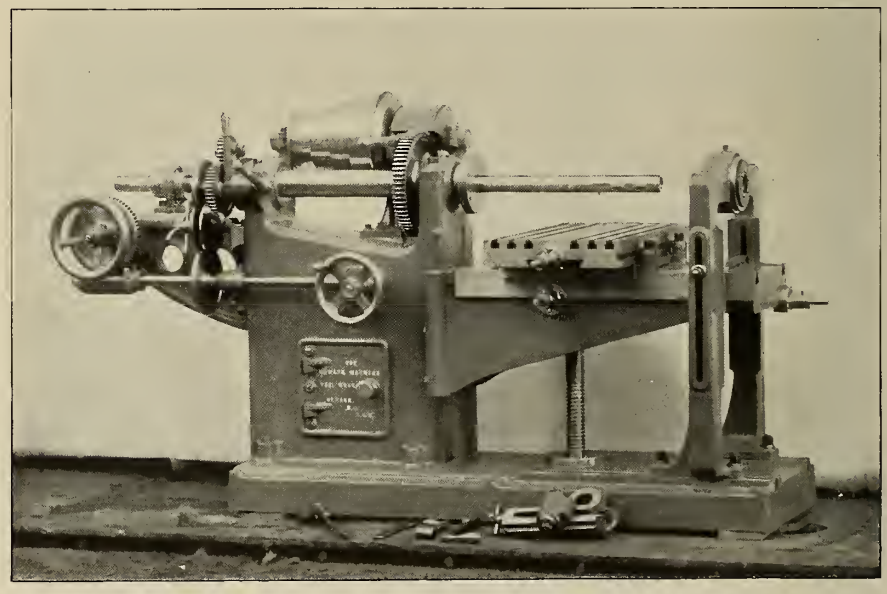


BORING MACHINE BUILT BY THE NEWARK MACHINE TOOL WORKS, NEWARK, N. J.

The cut being taken with the table and carriage bolted hard and fast, it is evident that the work is under the most favourable conditions for rapid and accurate results. The boring bar, sliding within the main spindle and revolving with it, can be handled by the operator with the greatest ease. It can be advanced a thousandth of an inch, to try

the cut, or it can be withdrawn, to measure the bore, at the rate of a foot for each turn of the feed hand-wheel. Moreover, the feed can be stopped and changed with quite as little effort.

Compare this with the trouble of lifting a bar, weighing, perhaps, half a ton, poking it through the cylinder, and putting it on the lathe centres. The length of the boring bar need be but a little more than that of the bore, instead of twice the length, as is the case with a lathe. Consequently, the boring bar is far more rigid in the horizontal boring machine than it is in the lathe, and it amiss to direct attention to the very high quality of workmanship and the extreme accuracy of fitting which this tool demands. The workman in setting should be able to rely upon the squareness of the carriage. Otherwise, he will need wedges or packing pieces and forfeit the machine's natural advantages. All the guiding surfaces must be square and true. Should the surfaces which control the movement of the yoke be out of square with the axis of the bar, the stub bar revolving in the yoke bush would turn on a curved axis and the resulting cylinder bore be out of line.

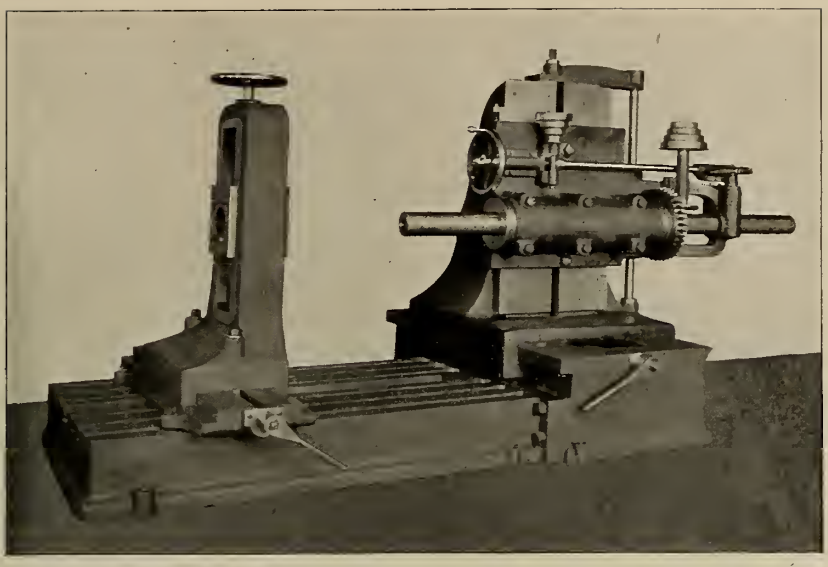


ANOTHER FORM OF NEWARK MACHINE TOOL COMPANY BORING MACHINE.

can be used as a long or short bar as the occasion may require. It is the practice to use short bars,—"stub" bars,—in connection with the main boring bar, one end of the "stub" revolving in the yoke, the other being keyed rigidly to the main bar. These short bars carry the cutter head, and can be of any diameter, depending only on the size of the bar, and the amount of stiffness wanted.

Parallel bores and holes in different horizontal planes can be finished without resetting the work. It may not be The hole in the spindle, as well as all the fitting of the spindle, requires the greatest accuracy possible and perfect finish. In fact, this tool belongs to the milling machine class in grade of workmanship, and with a few alterations in details it can, indeed, be used to great advantage for many kinds of plain milling.

In describing, now, the machines which have been selected as best representing their class, we shall rate them according to the diameter of the boring bar, for it is this dimension which gov-



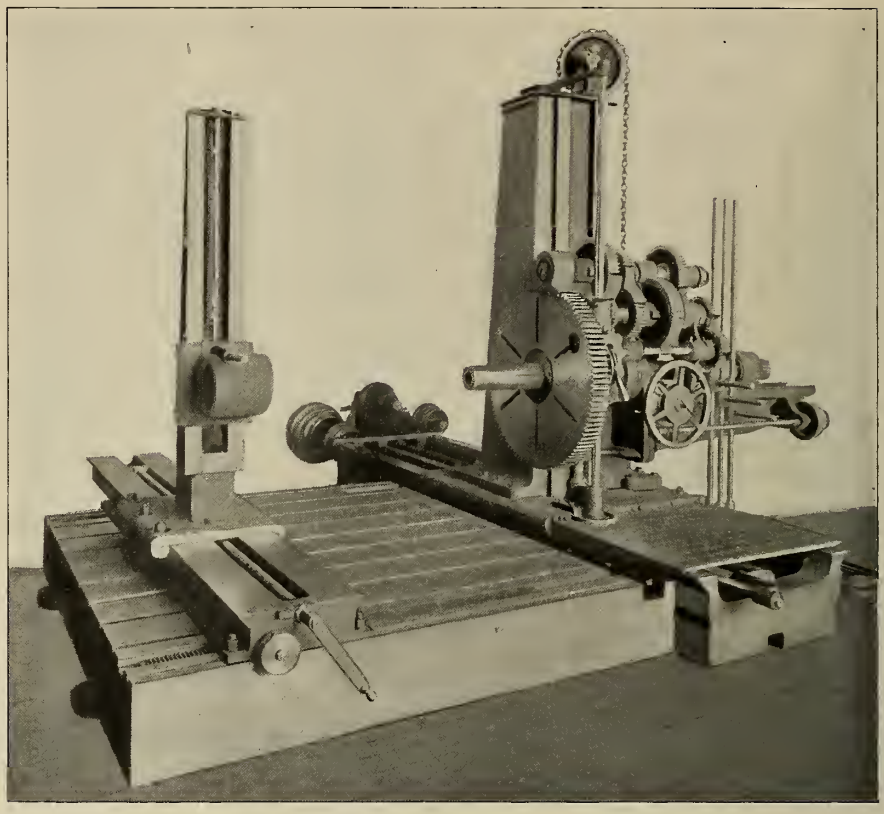
HORIZONTAL FLOOR-BORING MACHINE BUILT BY THE NEWTON MACHINE TOOL WORKS, PHILADELPHIA.

erns the other proportions. The Warner & Swasey horizontal boring machine on page 518 has a 2½-inch boring bar, and, therefore, its use is confined to very small bores. In fact, it may be said that it is a drilling rather than a boring machine. It excels in rapid and very accurate drilling or boring for manufacturing purposes, more particularly for parallel holes, or those which have to be very true and straight. It is distinctively a tool of precision. This purpose is revealed by the design of the machine. The massive and rigid base preserves the strict alignment of the moving surfaces.

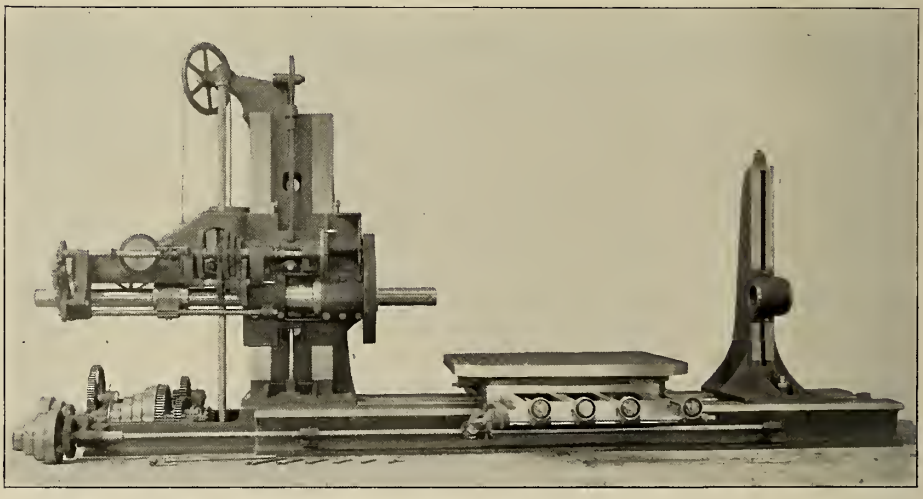
The table is guided in its vertical movement by surfaces of very unusual length; in fact, all the bearing surfaces are of the most liberal proportions, in order to reduce the natural wear and to retain the original adjustment of the machine. There is the slow and quick hand feed of the bar, as well as a power feed, driven by a pair of cones. A very stiff, steady rest, or yoke, composed of three pieces, bolted together, serves a double purpose; it ties the end of the table and holds the end of the stub bar, when one is used. In its movement it is guided by the planed surfaces of the bed plate to which its feet are bolted.

The Bement, Miles & Co. machine on page 518 has a boring bar of three inches diameter. The size of this machine makes it necessary to place it on a foundation; hence the bed plate is much lighter, proportionately, than that of the machine just described. The boring bar, fed by a rack and pinion, is sufficiently long to give a total traverse of about twice the length of the feed motion bracket, the feed bush holding the bar at several points. The automatic feeds are obtained by cone gearing, and may be operated from both sides of the machine.

The machine built by the Newark Machine Tool Works, shown on page 519, has a 4-inch bar. The automatic feed is by an original and improved arrangement of the well-known Sellers friction feed disks. This feed can be reversed, changed or thrown out without stopping the machine. The yoke of this machine is provided with double bushings, one fixed, the other turning with the bar. This puts the wear between the bushes and spares the bar, which is the more expensive piece of work.



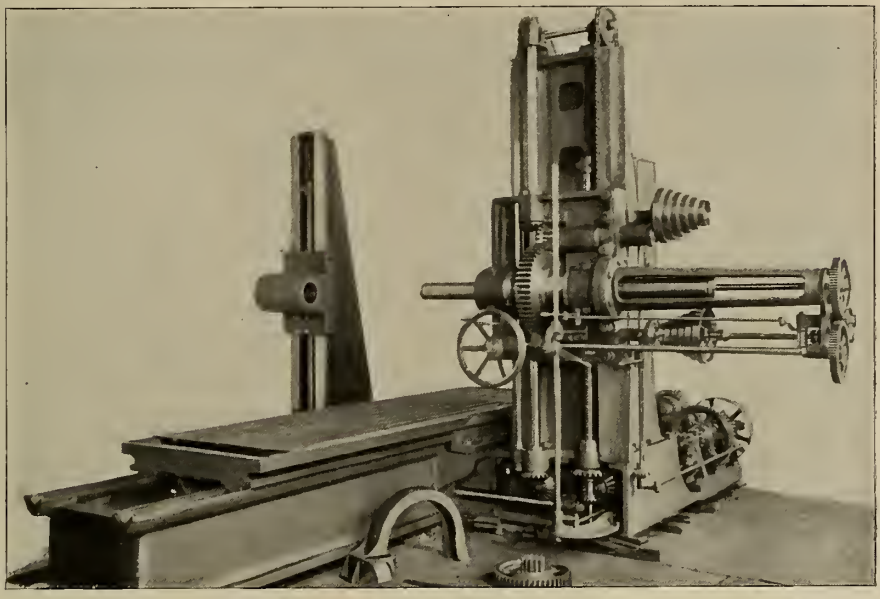
FLOOR-BORING MACHINE BUILT BY MESSRS. BEAMAN & SMITH, PROVIDENCE, R. I.



BORING, DRILLING AND MILLING MACHINE BUILT FOR THE WASHINGTON, D. C. NAVY YARD BY MESSRS. BEMENT, MILES & CO.

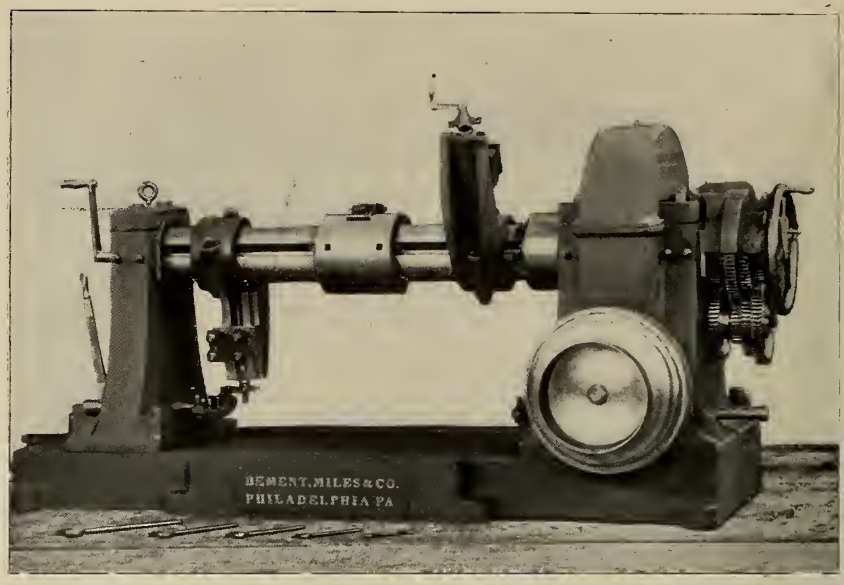
The cut of the little machine, with 2¾-inch bar, shown on page 520, exhibits the writer's latest design. It will be observed that the driving cone is placed at the side of the main spindle and above it. The reducing gearing is placed within the cone, and a pinion on the cone-shaft drives the spindle gear. This is a triple gear system, in place of the usual double or back-gearing, and it possesses the following advantages, which seem to the writer to be of considerable importance:—There is nothing in the way of the driving belts, and all the speeds are useful. In the usual construction, with back-gearing, there are always several speeds too fast to be used. In addition to the ease with which the change can be made from the quick to the slow-speed rates, we gain the first essential to rapid production, superabundant power.

Space limits compel the writer to leave the very interesting details of these machines to the study of the reader, but before passing to the next type of boring machine, the attention of those interested in the subject should be directed to the remarkable work done by several of these tools at the United States Army and Navy gun shops, citing, as one example from many, the boring of the hydraulic recoil cylinders. The recoil is received upon pistons moving in twin cylinders, filled with liquid, the clearance between piston and cylinder wall fixing the pressure and the piston speed. The cylinder heads are secured by a thread cut in the end of the cylinder. This is a very nice bit of work, demanding perfect accuracy and mechanical truth. It is completed at one setting, even to the thread cutting.



UNIVERSAL HORIZONTAL BORING AND DRILLING MACHINE BUILT BY MESSRS. BEMENT, MILES & CO.

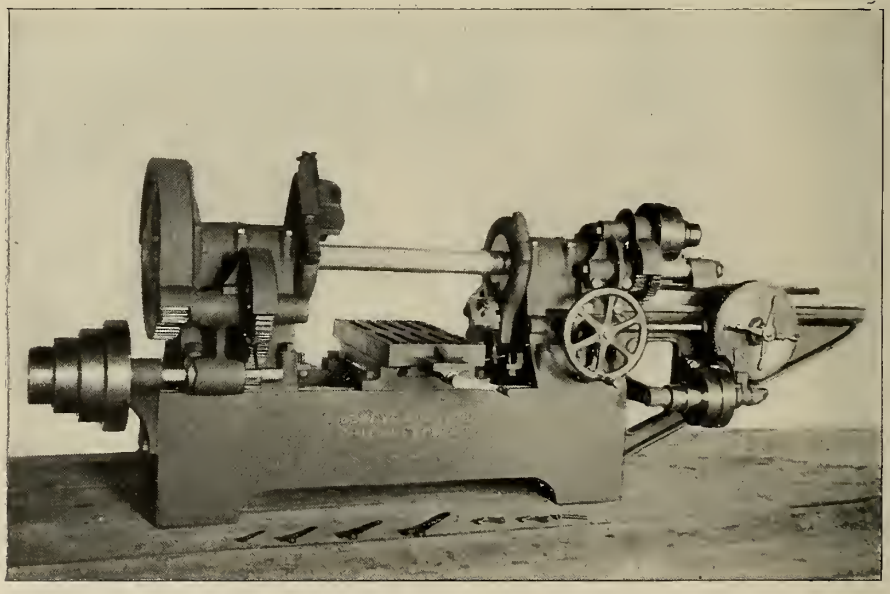
To illustrate how excellently this tool may be adapted for milling, the writer would call attention to the remarkable use of it, made by the American Gas Furnace Company at Elizabeth, N. J. This company build pressure blowers with a large internal boss in which slide wings. The slots in the boss for these wings, as well as the wings, are milled and finished at one cut, so accurately, that they are air-tight, no scraping being needed. These slots reach



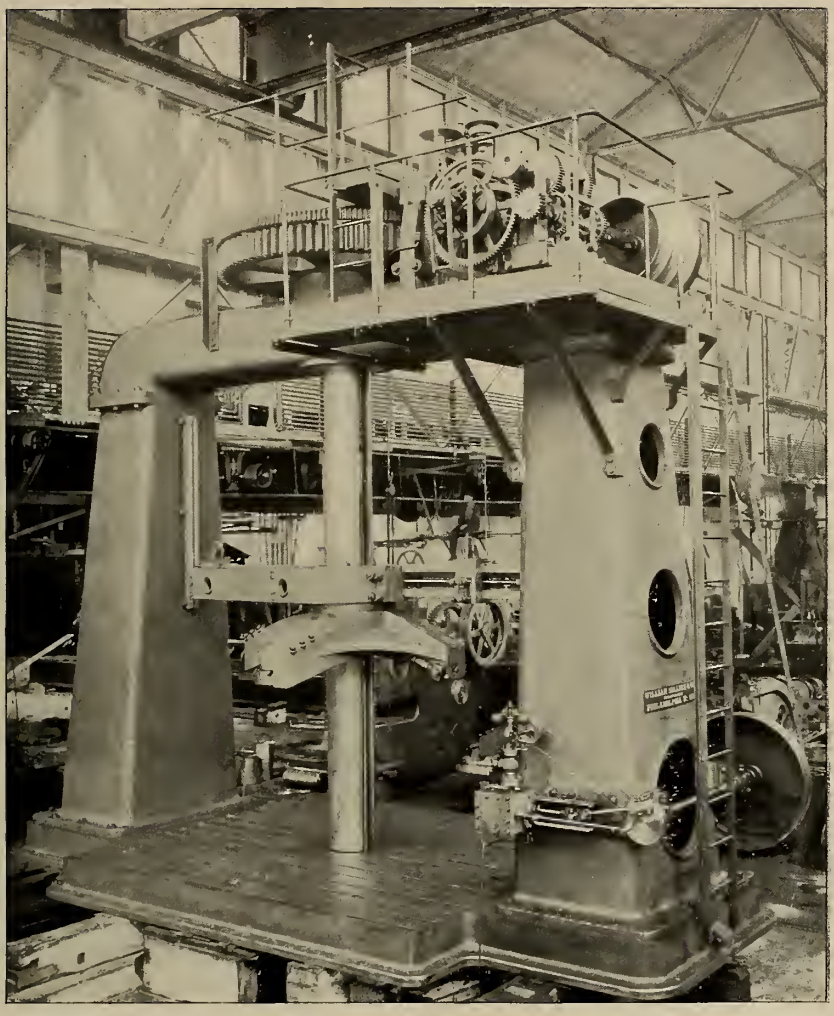
NO. 2 LOCOMOTIVE CYLINDER BORING MACHINE BUILT BY MESSRS. BEMENT, MILES CO.

30 inches in length, by 6 inches deep, and but one inch wide.

The horizontal boring machine is not suited for heavy pieces weighing more than, about, 5000 pounds. For weights in excess of this it is easier to set the boring machinery to the piece. For this purpose, therefore, there is another class of machines in which the work is placed on a bed plate, practically level with the floor, the boring bar and its mechanism being adjustable to it. These may be named floor-boring machines, and their description will be



NO 1 CYLINDER BORING MACHINE BUILT BY MESSRS. BEMENT, MILES & CO.

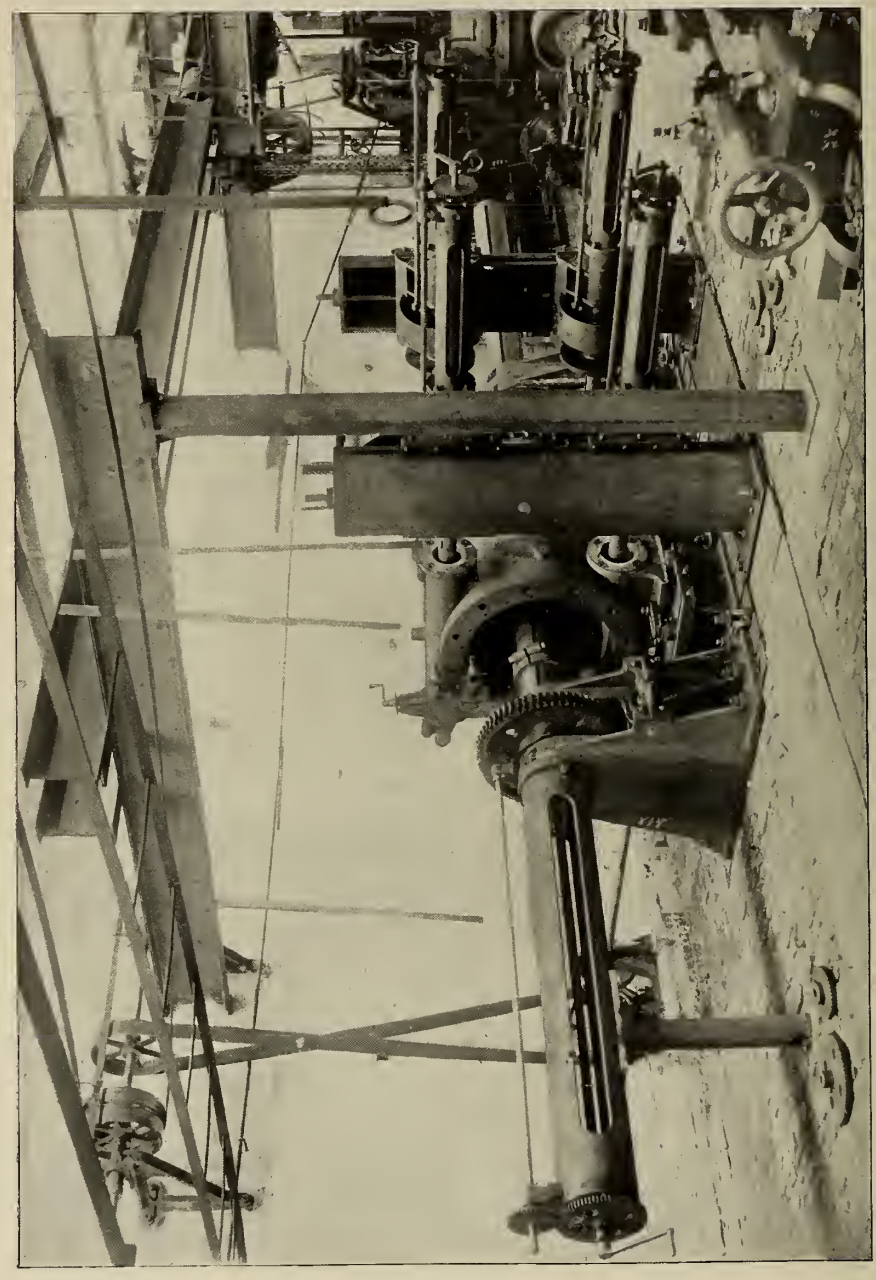


A VERTICAL CYLINDER-BORING MACHINE BUILT BY MESSRS. WILLIAM SELLERS & CO., INCORP., PHILADELPHIA.

commenced with the admirably simple design of the Newton Machine Tool Works shown on page 521.

The work being bolted to the floor bed-plate, the bar is adjustable vertically and horizontally to it. The outer bar support is set, also, to meet the bar, which is five inches in diameter. It is driven by a phosphor-bronze worm wheel and hardened steel worm, with hard steel and bronze thrust collars, in combination. This is a favourite method of driving with Mr. Newton, giving excellent result in his hands; but the design requires much experience, with great care and skill, and those who are unfamiliar with the condition under which worm gear will not work had best content themselves with admiring the design, without imitating it.

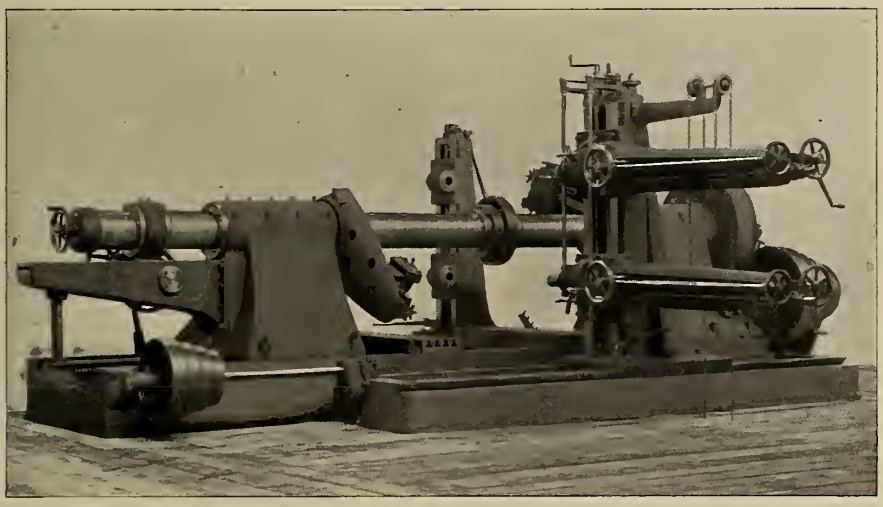
In the Beaman & Smith floor boring machine shown on page 522 the same problem receives a different solution. The designer has resorted to spur gearing entirely, both for the driving and for the feed motion. The boring bar is



A CORLISS ENGINE CYLINDER AND VALVE CHAMBER BORING MACHINE USED AT THE WORKS OF H. BOLLINCKX, LTD., BRUSSELS, BELGIUM.

driven by a face-plate spur gear, giving a very powerful, steady movement. This excellent design is shown so clearly in the illustration as to need no further remarks.

The Bement, Miles & Co. machines, on pages 522 and 523, are types of floor borers in which movement can be given to the work in a horizontal plane. The universal machine, on page 523, is constructed with a planer bed and tables, the boring mechanism taking the place of the planer uprights. The table has a power traverse back and forward, with slow and quick feeds. The machine on page 522 has a revolving, in addition to a cross-feed, table. The work can be moved horizontally in any direction. This machine is designed for milling, as well as for boring.

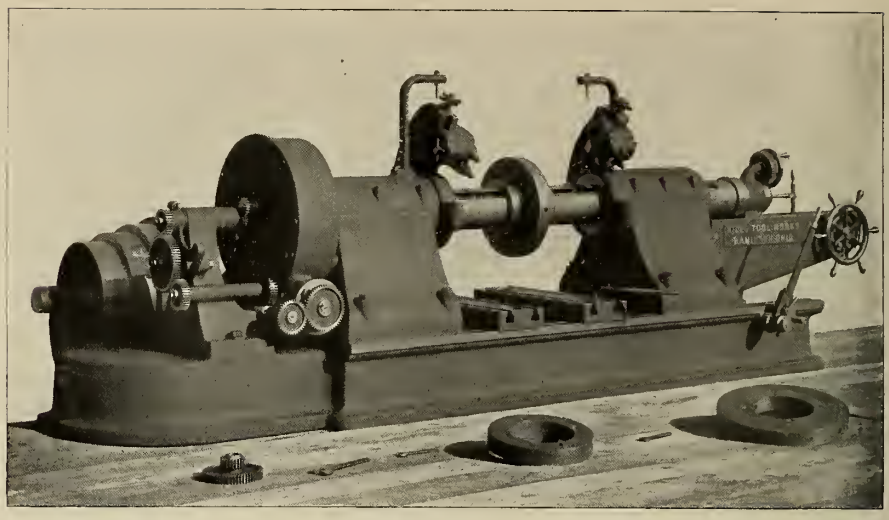


MACHINE FOR BORING CORLISS ENGINE CYLINDERS AND VALVE CHAMBERS SIMULTANEOUSLY, BUILT BY THE NILES TOOL WORKS CO., HAMILTON, OHIO.

Proceeding to the machines which are more special in character, we find so many and varying designs that we are bewildered in attempting to describe them. At the best, it is possible to touch upon a few only, from the great number. There are three ways in general usage to employ the boring bar. The bar may turn between centres, as in the lathe class of machines, the work being moved or fed along. Again, the work may be stationary and the bar both revolve and feed, as it does in the horizontal boring machine; or the work may be fixed and the bar revolve, while the cutter head is fed along the bar by a lead screw. Both the second and third methods are in frequent use in these cylinder borers.

On page 524 are shown two cylinder borers constructed by Messrs. Bement, Miles & Co The No. 1 machine is provided with a 5-inch bar, and was made to bore locomotive cylinders as large as 14 by 24 inches. The cylinder is set on a cross-feed table, which affords the adjustment in a horizontal plane, it being intended that the vertical adjustment shall be effected by special blocking. The bed is of the most substantial character, carrying a head at each end. The bar is driven by the cone and gearing on the left-hand head, and is fed at the right-hand head by means of details resembling those of a horizontal boring machine. There are two facing heads, to finish both ends of the cylinder while the boring is going on.

In the No. 2 machine, shown at the top of page 524, the boring is performed by feeding the cutter head



MACHINE FOR BORING AND FACING LOCOMOTIVE CYLINDERS, MADE BY THE NILES TOOL WORKS CO.

along the bar, which has a movement of revolution only. In this machine the bar is nine inches in diameter. To set the work, the outer bearing and the facing head are removed. The work is then bolted to the bed and the bearing put back. The bar is driven by worm gearing and the screw is driven by the cone gearing, as shown.

On this page is shown a cylinder boring machine built by the Niles Tool Works Company. In this massive and well-proportioned tool the cutter head is fed by a screw; but, in addition, the bar can be withdrawn to permit the work to be set without removing the head. The 9-inch bar is driven by tangent gearing of great power.

The previously mentioned vertical cylinder boring machine, built by William Sellers & Co., Incorp., for the Newport News Ship-Building and Dry Dock Company, of Newport News, Va., is certainly a remarkable example of the highest development of American tool building and engineering. This important machine, shown on page 525, was designed for boring cylinders from 4 to 9 feet in diameter, and up to 10 feet long. It consists of a large bed-plate, carrying two massive uprights 13 feet apart, joined at the top by a deep cross-beam, which carries the driving and feeding machinery and provides the upper bearing for the bar. The latter, which is 16 inches in diameter, runs in a bushing in the cross beam, and is supported by a step bearing in the bed-plate. This bar is so arranged that it may be lifted up to clear the work when cylinders are being put into the machine or taken out. In lifting the bar, it passes through the large driving and feed-gears without disturbing them, as they are supported by the rotating bushing in which the bar slides.

Upon the bar is a moving sleeve, provided with a central flange, and to this sleeve are secured the cutter heads for various sizes of cylinders, and the double facing-rest which is used for turning off flanges of cylinders up to 10 inches in diameter. The traveling sleeve is supported upon two feed-screws, which are provided with a hand adjustment, a power-feed, variable from 1-16 in. to about 1⅜ in. per revolution of bar, and a rapid power-traverse by means of which the head can be quickly raised or lowered while the bar is standing at rest or rotating in either direction.

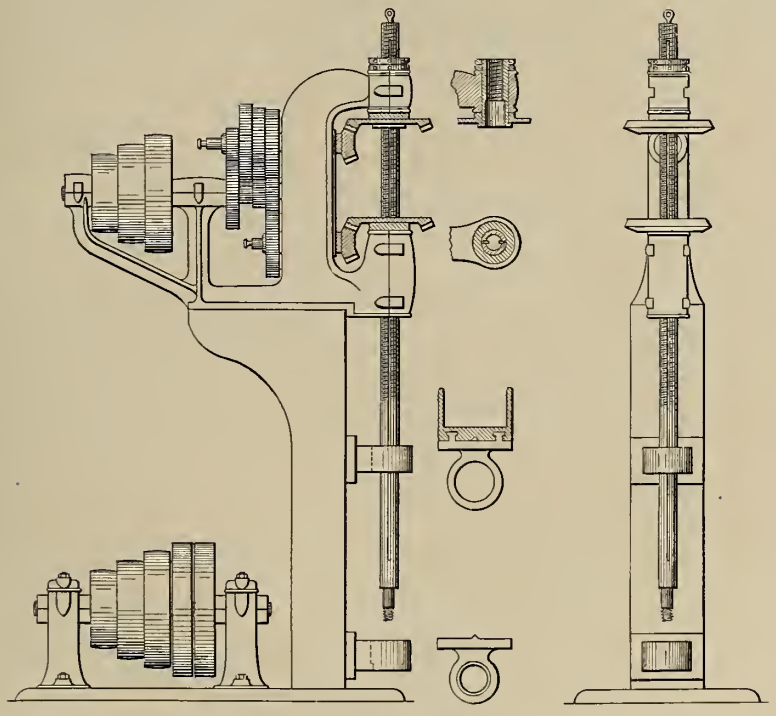
The motive power is usually furnished by an 8″ × 8″ engine, bolted to one of the uprights, and carrying a large cone-pulley on the end of the crank shaft.

This cone is connected by belt to a corresponding cone on the cross-beam, from which the various movements of the machinery are actuated. The controlling levers are grouped together for convenient manipulation by an operator standing on a platform on the top of the machine. this platform being accessible by a ladder on one of the uprights. The variations in the power-feed are made through a set of change wheels, and can be set for feeding either downward or upward.

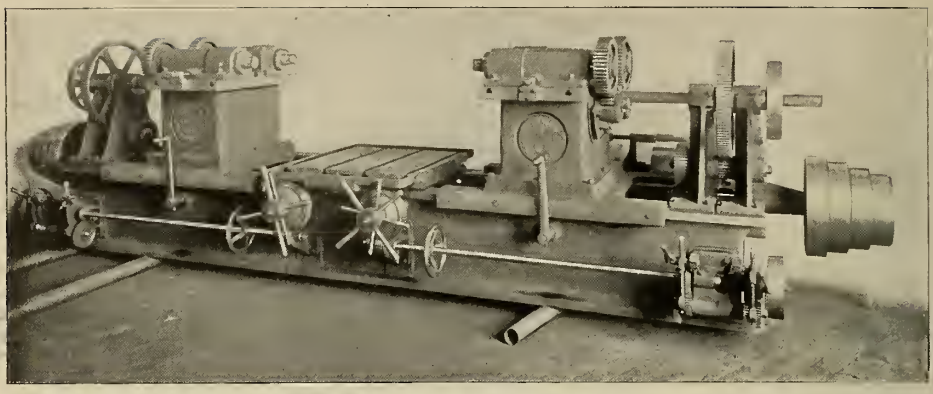
The cutter-heads, of which there are three, covering the whole series of diameters, are arranged with adjustable tool-slides, and are especially designed to bore to the bottoms of cylinders having a solid lower head. The cutter-heads are also arranged so that the same tools can be arranged to bore in either direction. In addition to the variations of speed obtainable through the cone-pulleys, the adjustable governor of the engine permits still further variation in the driving speed. The train of gearing consists entirely of straight spur and bevel wheels, and is thus far more efficient and durable than any arrangement making use of worm gearing .

From the consideration of the last group of tools, designed for cylinder boring in general, we pass to some machines built for particular kinds of cylinders, which, being widely known, will possess general interest. The acceptance of the Corliss as the most economical type of steam engine has become so universal that many boring devices for this class of cylinders would be looked for; in fact, every Corliss engine manufacturer has his own favourite way of doing this work, and no method is generally accepted as the best.

The Corliss cylinder has four valve ports, cylindrical bores, crosswise to the



A MOULD-BORING MACHINE MADE BY THE NEWARK MACHINE TOOL WORKS, NEWARK, N. J.



A FOUR-SPINDLE MACHINE FOR BORING DUPLEX PUMP CYLINDERS, BUILT BY MESSRS. BEAMAN & SMITH.

main cylinder, as shown in the illustration on page 526, which represents a very interesting Corliss cylinder-boring machine built by H. Bollinckx, Ltd., Brussels, Belgium, for their own use. This tool bores the steam cylinder and all four valve cylinders simultaneously. It covers a working range of from 16 × 32 to 50 × 72 inches. The boring is done by the cutter-head fixed to the boring bar, the bar being fed through the cylinder. The two bearings for the main bar and the standards for the valve boring mechanisms rest on the same heavy bed-plate to which the cylinder is fastened. The bar is driven by worm gearing. On the right-hand side the two standards will be seen, each carrying two complete boring mechanisms, one for each valve port. It is of interest to note that the cutting speed is stated to be from 14 to 16 feet a minute, and that Mr. Bollinckx is satisfied to finish a 20 × 40-inch cylinder in 60 hours.

In the United States, this would be considered slow, and there are American shops in which better time is being made using a horizontal boring machine of the usual type. Perhaps this slow speed is caused by conditions not mentioned by Mr. Bollinckx, such as unusually hard metal. The Bollinckx Company ream the cylinders after boring, replacing the boring heads by adjustable-blade reamers. So far as the writer is aware, no American Corliss engine builder has gone to this refinement.

On page 527 is shown a much larger machine for a like purpose, built by the Niles Tool Works Company. In this excellently proportioned machine the cutter-head is drawn along the bar by a feed screw while the bar revolves. The driving is performed by tangent gearing. The bar is withdrawn from the driving head to let the work pass. There is but one standard with two boring heads. This should be sufficient, as there is always ample time to finish the valve ports while the steam cylinder is being bored.

There is a very simple little trick for producing extremely accurate bores, by which results can be obtained that can be had in no other way. If, in boring, the cutter-head be drawn through the cylinder held in a vertical position, the resulting bore will be absolutely straight. Use is made of this in boring the printing press moulds, in which ink distributing rolls are cast. These rolls are made of gum, and they revolve at a velocity high enough to distort their cross-section by centrifugal force, should they be out of round. It will be understood that an even distribution of ink can be had only from rolls both straight and true.

With this explanation, the construction of the machine shown on page 529, which was designed and built by the writer, will be easily grasped. The

boring bar has a thread cut upon the upper portion, as well as a pair of keyways on opposite sides. The upper bevel gear fits the thread, while the lower gear has a pair of feathers fitted to the keys and turns the bar. When the two gears revolve at the same speed, the bar has no motion vertically; but when the two bevel gears turn at varying velocities the bar is fed up or down. While this principle is familiar, it is believed that the present arrangement is novel.

The power received on the three-step cone is transmitted through the nest of gears to the bevels. The four gears on the intermediate shaft are fixed; those on the top and bottom shafts are loose, and can be fixed, one at a time, by a sliding key. Three feeds are obtained by fixing the lower gear and any one of the three uppermost gears.

After the mould has been bored, the bar is returned rapidly, by letting the lowest gear revolve idly and by throwing into action the extreme left-hand pair. Then the bevel-gear nut revolves while the driving gear stands still. The cutter-head is keyed to the end of the boring bar and is pulled vertically upward through the mould, which is held by set-screws in the chucks which are shown. The mould is reamed in a similar way.

The illustration on the opposite page shows a machine for boring duplex pump cylinders, both steam and water cylinders being bored at the same time.

It is worth noting here also that the Newton Works make a four-spindle electric car motor boring machine. The motor is encased in a frame in which there are four holes for the shaft bearings.

The machine is made exceptionally strong, the spindles being 6 inches in diameter, and the whole machine being designed in proportion and weighing 31,000 pounds. The spindles are adjustable, so that different sizes of motor frames can be bored.

In this view over the field many important tools have necessarily been omitted. Nevertheless, an idea may be formed of the great strides and revolutionary changes which the last few years have witnessed in this branch of machine tool building.

THE PRESENT STATUS OF ELECTRICAL ENGINEERING IN THE UNITED STATES.

By Dr. A. E. Kennelly.

BY far the greater proportion of electric development has come within the past decade and a half. In a recent presidential address before the American Institute of Electrical Engineers the writer pointed out, as illustrative of this, that in 1884 the words ammeter and voltmeter were just commencing to be generally recognised, and of electric traction there was none. At the present time the capitalisation in electrical applications in the United States is estimated at about $1,900,000,000.

In 1884 a 50-kw. dynamo was considered a large machine, while a 100-kw. Edison steam dynamo was justly called a "Jumbo." At the present time the largest size of generator built or building is of 4600 kw. capacity. The price of dynamos in 1882 was about 20 cents per watt of output, while dynamos of similar running speed in comparatively small sizes, without switchboards, now cost about two cents per watt. The great reduction in price represents the aggregate result of the very large amount of labour devoted to this branch of engineering in the last fifteen years.

It is interesting to notice that the efficiencies of continuous-current dynamos have not made any marked nomi-

nal advance during the past fifteen years, though their output per unit of mass has considerably increased. Thus a 50-kw. dynamo tested at the Philadelphia Electrical Exhibition in 1884 is stated to have had an efficiency of approximately 92 per cent., and this would be considered a satisfactory performance in that size of machine to-day. But, whereas the output then was only six watts per pound of net weight, the output of a machine of similar rating and speed to-day would be about ten watts per pound. In other words, the efficiencies of the best dynamos of 1884 were already so good that it has not paid, at existing costs of power, to markedly improve them, and such improvements in material and design as have since been effected have enabled manufacturers to increase the rating or yield, and, therefore, the cheapness of the machines. It seems probable, moreover, that this will continue to be the direction of future progress. We scarcely can desire more efficient machines than the best we have now, but we shall always desire cheaper and more powerful machines, and shall welcome any improvements which lead to them.

Another evidence of the development in dynamo machinery is its improved appearance. Formerly the only claim possessed by such apparatus was utility. More recently grace, the expression of unconscious power, has supervened, and the modern dynamo is often pleasing to look upon as well as useful to operate.

The cost of generating a kilowatt-hour of electric energy from steam for electric lighting appears to have been at least 7.5 cents at the 'bus bars in 1884. At the present time the cost of delivering a kilowatt-hour to large street railway systems from steam is only about one cent, and the power house operating costs are reported in some cases as low as half a cent. In municipal electric lighting systems supplied at low pressure from steam central stations and hampered by relatively heavy distributing expenses, the retail price of the kilowatt-hour varies from 20 to about 4½ cents, according to the locality and quantity consumed. Niagara power is now sold to consumers in Buffalo at rates varying, according to the amount delivered, from two cents to slightly less than two-thirds of a cent per kilowatt-hour delivered.

The price of a 16-c. p. incandescent lamp sixteen years ago was about $1. Now it is about 18 cents. The best lamps at that time, under laboratory conditions, gave about 0.28 mean horizontal normal British candle-power per watt, and under commercial conditions about 0.20. The highest pressure for which they could then be obtained was about 110 volts. At the present time lamps are obtainable giving normally 0.4 mean horizontal British candles per watt, while under commercial conditions the average lamp normally develops about 0.25 candle per watt. They can also be obtained (at 0.25 candle per watt) for pressures up to 240 volts, and are frequently installed on 220-volt mains.

Arc lamps were already so far advanced in 1884 that comparatively little improvement in their effectiveness has taken place, the gain having been made in economy of operation. Thus the carbons which cost at that time about six cents apiece now cost about two cents apiece. The enclosed arc lamp has of recent years become popular, owing to its diffused light and a carbon life of from 100 to 150 hours.

It has been estimated that about $600,000,000 have been invested up to the present time in electric lighting stations and plants in the United States.

The best storage cells tested at the Philadelphia Exhibition of 1884 gave a yield, under laboratory conditions, of 3.4 watt-hours per pound of electrodes with an energy efficiency of 69 per cent. when discharged at the mean current density of 12 ampères per square foot of negative plate surface; while the deterioration was comparatively rapid. At the present time storage cells are in use giving, under laboratory conditions, a yield of from five to six watt-hours per pound of charged cell, with an energy efficiency of about 85 per cent., when discharged at a current density

of 4.8 ampères per square foot of negative plate surface. There are now storage batteries installed in the United States to the aggregate capacity of about 56,000 kilowatt-hours. The largest installation has 166 cells, weighs 500 short tons, and has an eight-hour discharge capacity of 22,400 ampère-hours, or 3136 kilowatt-hours at 140 volts pressure.

A very great development has taken place in the direction of electric traction, by virtue of which the horse car, once so well-nigh ubiquitous in city streets, has almost entirely disappeared, while electric locomotives of 1500 H. P. have even made their appearance on steam railroad tracks. The introduction of soft cast steel has been very advantageous to the electric motor, enabling its output to be increased from 5 watts per pound of net weight in 1884 to about 14 watts per pound in street-car motors at the present time. It is estimated that there are to-day in the United States about 14,000 miles of electric railroad, with a nominal capital of about $1,000,000,000, and employing about 170,000 men.

The electric transmission of the power of falling water is a branch of engineering that has come into service since 1884, and is making rapid strides owing to the recent successful employment of high voltages and multiphase alternating currents. It has been estimated that about 150,000 kw. of this class of machinery is installed on the North American Continent, commercially transmitting power to various distances up to 85 miles at various pressures up to 30,000 volts.

The alternating-current induction motor has become very popular in recent years, mainly owing to its powerful starting torque and its freedom from commutator and brushes. A burned-out armature, the perpetual source of dread in motor operations of days gone by, is practically unknown in this type of machine, even when put to severe service. Indeed, its depreciation under fair conditions appears to be as low as in any class of rotating machinery.

The alternating-current transformer has been correspondingly improved, developing, in large sizes, an efficiency of about 98.5 per cent., and an output, when cooled by external power, of about 100 watts per pound of weight.

The principal engineering value of electricity to-day lies in its adaptation to the transmission of power through mills or cities, or from some locality where power is cheap to others where it is dear. A steel rope by its bodily motion can transmit, with appreciable friction and depreciation, some hundreds of kilowatts to a distance of some thousands of feet. A bare quiescent copper rope, ½ in. in diameter, and supported on poles, can, by maintaining an effective potential of 10,000 volts by the motion of electric waves over its surface, transmit, say, 2500 kw. with an energy loss of two-thirds per cent. per mile, and with practically no depreciation except that of the poles and supports.

The use of high pressures has thus become more frequent during the last few years. Alternating-current generators are now made to supply 10,000 volts at their terminals, and insulation testing sets have been made for producing alternating pressures up to 100,000 volts effective.

The application of electric power to domestic use and household comforts, irrespective of illumination, has made steady progress. In the large cities the fan-motor day load of summer is, in the aggregate, a perceptible quantity, while electric ranges and heaters on a small scale have found favour through their convenience.

In telegraphy, comparatively little change has recently taken place beyond the substitution of the dynamo or dynamotor for the voltaic battery, and of copper line wire with some 5 ohms per mile for iron wire with some 13 ohms per mile. About 1,000,000 miles of telegraph wire are now strung on about 200,000 miles of pole line in the United States, connecting about 25,000 offices, and working an invested capital of about $150,000,000.

In the United States, the uniformity of the closed-circuit Morse system, sim-

plex, duplex, or quadruplex, is varied only by an occasional Wheatstone set. This crystallisation of methods is not due to any lack of invention or capability of improvement in signalling speed, but rather to the apparently settled belief that the present systems are the most economical under existing conditions of traffic. In long submarine telegraphy, the pressure of increasing traffic has made itself more distinctly felt, but the physical difficulties in the way of attaining high speeds have, as yet, been obviated only in part by an increased expenditure in copper and gutta-percha, to obtain a diminished conductor resistance per mile. Wireless telegraphy has entered its experimental stage, and bids fair to enter practical service in the future, at least within a limited range.

In telephony the most notable improvement in recent years has been the general substitution of metallic circuits, for ground return circuits, with great advantage to the convenience and effectiveness of the service. At the present time conversation is carried on commercially up to a distance of 1800 miles, and quite frequently at distances of 1500 miles. There are at the present time in the United States about 1,000,000 telephones connected with the telephone service of the country, employing a capitalisation of about $100,000,000, 400,000 stations, and about 900,000 miles of wire. Every day about 17,000 employees make on the average more than 3,000,000 connections. About 300,000 miles, or nearly one-third of the total length of telephone wires, have within the last few years been made up into aerial and subterranean cables within city limits, owing to the reduction of the electrostatic capacity effected in such cabled wires to less than one-twelfth of a microfarad per mile.

A considerable development has occurred in electrothermic and electrolytic processes. More than 4000 kw. of Niagara power are now employed in such processes. Among electrochemical processes are the electrolytic refining of copper to the extent of about 150,000 tons annually, the production of aluminium, the production of sodium and alkalis, and the treatment of ores. Among electrothermic processes are the production of the carbides of silicon and calcium in steadily increasing quantities.

In electrotechnical theory considerable advance has been made of recent years, particularly in the study of alternating currents. Accompanying the expansion of knowledge in the various branches there is a tendency among them to combine and unite into one general theory. Thus, while the low-tension electricity of dynamo origin was once regarded as something so dissimilar to high-tension electricity as to require separate treatment and classification, to-day the high tensions derived from alternators through step-up transformers so far invade the territory of so-called frictional electricity that a dividing line between the two classes can no longer be maintained. Similarly telephony and telegraphy are coming to be regarded as sub-classes of alternating-current power transmission, while electricity and magnetism cannot properly be studied apart.

GAUGING THE CIRCULARITY OF BOILER FURNACES.

By T. Messenger, A. M. Inst. C. E.

AT a recent meeting of the North-East Coast Institution of Engineers and Shipbuilders the writer offered a paper on an instrument for gauging the circularity of boiler furnaces and cylinders, and producing a diagram which has already met with the approval of some of the Board of Trade surveyors, and others most interested in this question, who have seen it.

The invention relates to an instrument or apparatus for internally gauging and testing the circularity of cylinders, and delineating the same on paper, and is designed more particularly for use with cylindrical furnaces.

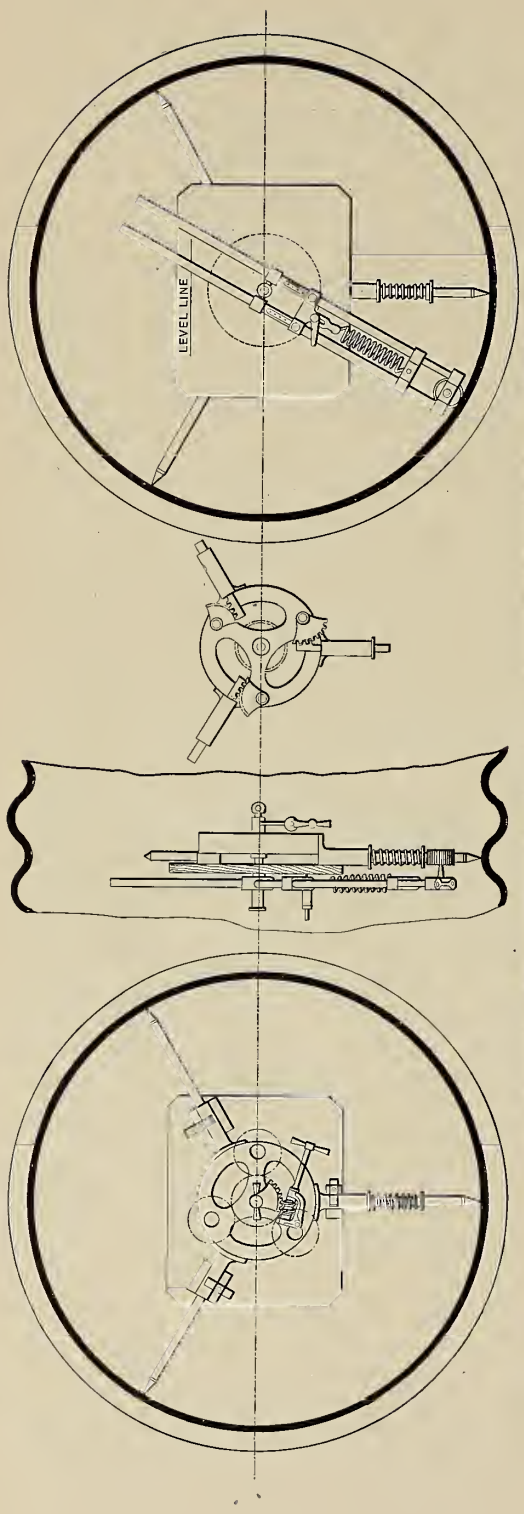
Of late years the steam pressure in boilers has been greatly increased, particularly in marine boilers of the cylindrical type having circular furnaces. Such furnaces are liable to become distorted after use, and it is necessary to frequently gauge them to ascertain any deformation which may exist in them. This has hitherto been usually accomplished by measuring them with a telescopic gauge in different directions, but this method is extremely inconvenient and not nearly so exact as if these measurements were taken from the centre of the cylinder, *i. e.*, radially.

The object of this invention is, therefore, to take these measurements radially, and to produce a diagram on a sheet of paper showing the deformation, if any, existing in a section of the cylinder as compared with a true circle. It consists in arranging three telescopic legs radiating from a centre pin in such a manner that they all move outwards or inwards simultaneously and equally; they are placed at angles of 120 degrees one with the other, so that when the points of these three telescopic legs rest on the inner surface of the cylinder, the centre pin will always be in the centre of these three points, as explained further on.

A telescopic arm is suitably arranged and provided with a roller at its outer end, pressed out by a spiral spring, which arm works on the centre pin and is moved round the cylinder; the roller moves inwards or outwards as it travels round, following any irregularities in the cylinder, and if a pencil be fixed to the sliding piece in the telescopic arm, and pressed against a sheet of paper, it will describe on it a diagram or representation of the form of the cylinder and show if it be a true circle or any departure therefrom. From these representations it can be seen whether or not any deformation is to be found in that portion of the cylinder tested.

This result is obtained preferably in the following manner:—At the inner ends of each telescopic leg a toothed rack is fixed, and a cog wheel gears with each of these racks, the centres of these wheels being equidistant from the centre pin. A fourth wheel is placed centrally between, gearing into each of the three, the result being that the centre wheel, when turned in one direction, causes the three telescopic legs to move outwards, and if turned in the other direction, causes the three telescopic legs to move inwards, all simultaneously, and to an equal extent.

In placing the instrument into a cylindrical furnace, it is preferred to place one of the three telescopic legs verti-



AN INSTRUMENT FOR GAUGING THE CIRCULARITY OF BOILER FURNACES AND CYLINDERS.

cally, resting on the bottom of the furnace, and on this leg is placed a spiral spring to take the entire weight of the instrument, which enables it to be much more readily and quickly put in place. When the points of these three telescope legs all touch the furnace they are fixed as follows:— On the centre wheel spindle or axis is fixed a worm wheel, with which gears a worm, working in a pivoted frame, so that it can be instantly thrown in or out of gear with a worm wheel; and when the points of the three telescopic legs touch the inside of the furnace, the worm then gearing with the worm wheel, and being turned in one direction, immediately presses the points of the three telescopic legs outwards and locks them there, thus firmly fixing the instrument in position; the worm being turned in the opposite direction, as readily releases the instrument.

This worm wheel is on one side of the instrument, and the central pin first referred to is on the other side. On the central pin is suitably secured a drawing board on which a sheet of paper is fixed, and from the foregoing description it will be readily understood that if the telescopic arm, having a roller at its outer end, be moved around the furnace, and the pencil, attached to the outer portion of this arm which moves inwards or outwards with the roller, be brought into contact with the paper, a diagram will be produced accurately showing if the furnace be true or deformed. Although the pencil will revolve in quite a small circle compared with the furnace, yet the deformities, if any, will remain full size, and therefore will be apparently magnified in proportion to the circle. This enables these deformities to be much more easily read by the eye, and they can be measured as if they were full size.

It will be understood that several sets of telescope legs are required. The first set will take furnaces from 33 inches to 37 inches; the second, from 36 inches to 40 inches; the third, from 39 inches to 43 inches; and so on. The radial arm will take any furnace from 33 inches to 52 inches, and up to 60 inches, if required.

The instrument, when used in gauging a steam cylinder, should have the roller replaced by a pointer having a slightly rounded point, so as not only to show any deviation from a true circle, but also any scoring which generally exists in a worn steam cylinder.

The great importance of the diagram, when taken, is that it considerably magnifies any defects, and at the same time shows clearly at sight which are the major and minor diameters, thereby suggesting exactly the angles at which these dimensions should be taken when furnaces are examined for deformity, and also showing the boilermaker in which direction the furnaces require to be set into truth.

The pencil is preferably so set in the instrument as to describe a figure of a convenient size to suit a sheet of foolscap paper; and as this paper is usually soiled, it is best to take a tracing of this figure to be kept as a future record, and for comparison, say, every year, to ascertain the increase of deformation, if any.

The manner in which the pencil magnifies the evils when drawing the figure *A*, shown in one of the annexed illustrations, is very startling, and unless this is clearly understood it might lead to needlessly condemning a furnace. But this method of magnifying the evils is exactly that adopted when showing the profile of a railway, viz., the vertical scale being greater than the horizontal; otherwise the inclines would scarcely be seen, just as with this instrument any small deformity in the furnace is made apparent which otherwise would escape attention.

For finding the true circle *B*, to compare by scale with the figure *A*, an easy method is to bend a small lead wire around the figure *A*. This, opened out straight, gives the length of the circumference for obtaining the diameter of the true circle, *B*, for this comparison; or a cyclometer may be used.

The dotted line *C*, is reduced from figure *A* to the same scale as the true circle *B*, and the comparison of these two figures, viz., *C* and *B*, gives the true delineation to scale of what the real deformity is, and thus enables a true opinion to be formed at a glance, at the same time correcting the startling effect of that produced by the figure *A*, which so greatly magnifies these defects.

When measuring furnaces for deformity, as has hitherto been the custom by an ordinary telescopic gauge, only two

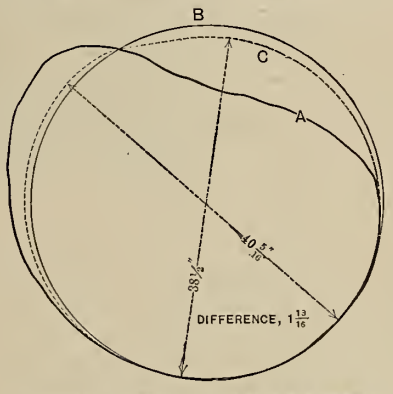


DIAGRAM TAKEN WITH THE INSTRUMENT.

diameters are generally taken in different directions, and these diameters entered in a proper form in figures, the subtraction of one from the other giving the difference, and so when wading through a sheet of these figures, say, for a vessel having 48 furnaces, one's mind becomes mystified before completing the investigation.

The great point in the magnified diagram is that it at once very clearly brings to one's mind the real defects of each furnace, and at a glance showing the real form in every point of its circumference.

The diagram is first taken with the instrument in each furnace, this, at a glance, showing in which direction they should be measured for the major and minor diameters, and also to the boilermaker in which direction to apply the hydraulic jack, so that this part may be

dealt with. The sheets of paper on which these diagrams are described are then taken to the office, and the scale for drawing the true circle *B*, is ascertained, as before explained. Having found this scale, the dotted circle *C*, is developed by radial ordinates to this scale; then these two circles *B* and *C*, show to scale exactly what the deformity is.

Current Topics.

If a current newspaper item may be believed, probably the most unique of known applications of electricity was recently discovered by a collector of old and rare books, who came across a peculiar specimen, bound in metal, with what seemed to be an electrical appliance at one end. The volume was a copy of the Protestant Episcopal Book of Common Prayer, translated into the language of the North American Indians of Dakota. The covers of the book had been carefully reinforced with substantial plates of nickeled brass, firmly fastened with five strong rivets on each side. At the top of each cover was an appliance for the insertion of an electric wire. According to the story told by the seller of the book, the work was used in its present form, in connection with an electric battery, by a missionary to the Indians. While the unconverted brave, whose soul the missionary desired to save, held the prayer book with his hands on both covers, thus forming an electrical circuit, the latter would surreptitiously turn on a gentle current, which sent mild, but appreciable, thrills through the frame of the savage. These he believed to be manifestations of the newly-found religion. It would be of some interest to know how many converts were manufactured by this rather unconventional bit of ecclesiastical apparatus.

While nearly every large hotel today has its own steam laundry, its electric lighting plant, and various other engineering accessories, it has remained for one of the New York hostelries to install a complete electroplating outfit for renovating its spoons and forks and other articles from which the silver has been worn off. The plant, which has been in operation for some time, is said to have fully justified the first cost of the outfit, and to have demonstrated the economy and feasibility of the scheme. The outfit comprises a 2 horse-power

electric motor driving a buffing machine, a plating dynamo, and four 25-gallon vats which hold the several solutions.

ANENT wire-wound ordnance, recently referred to in these pages, it is learned that the first gun of this kind ordered by the United States is expected to be delivered at the proving grounds at Sandy Hook, New York Harbour, some time in October. It is, at present, nearing completion in the Reading Iron Works, where the experts of the Brown segmental wire gun have the matter in charge. This gun will be of 10 inches bore, 45 calibres in length, and will weigh 30 tons. The contract specifies a normal initial velocity of 2600 feet per second, or 300 feet per second more than that required for any hooped gun now in the United States service. J. H. Brown, the inventor of this type of gun, is confident that it will stand a charge sufficient to raise the muzzle velocity to 2988 feet per second without material injury to its structure. From official experiments already made at the Sandy Hook proving grounds with an experimental 5-inch Brown gun, this initial velocity appears not only possible, but probable. These tests were made in December, 1893, and again in May, 1896, the first of the trials giving velocities of 3194, 3090 and 3088 feet per second, with average pressures of 65,000, 56,000 and 53,500 pounds per square inch, respectively. The difficulty with such velocities seems to lie not so much in the strength of the wire-wound gun as in the erosive action of all powders, though particularly the smokeless variety, on the rifling of the gun when high pressures are unavoidably employed. Lieutenant G. N. Whistler, of the Fifth United States Artillery, the engineering expert employed by the trustees of the Brown segmental gun, reports that in the unlined condition of an experimental cylinder, a "slight scoring, following the line of juncture of the segments, was noticed after a pressure of 43,133 pounds to the square inch. Since the cylinder has been lined, not the slightest scoring of any kind has been observed." As the erosion is most serious, in every description of gun, toward the breech, being caused by the gas of the explosive forcing its way past the gas check of the projectile before the latter has expanded sufficiently to fill the rifled grooves, the Brown segmental guns will have a lining tube inserted part of the way down from the breech, the rifling in the forward end being cut in the bare segments.

QUITE recently the United States government is said to have ordered twenty-five 5-inch and twenty-five 6-inch quick-fire guns of the Brown pattern for naval service. These guns will also be forty-five calibres in length, and must stand tests at 2600 feet per second initial velocity. The weight of the 5-inch gun is placed at 7600 pounds; and the weight of the 6-inch at 17,000 pounds. These guns certainly do not show any gain in lightness over British wire-wound guns, which are the only ones now in existence with which to compare them. For example, the standard British Q. F. wire-wound 6-inch gun of forty-five calibres weighs 16,576 pounds, as against the 17,000 pounds of the corresponding Brown gun. Of course, the Brown gun, by employing higher velocities, may obtain greater muzzle energy, but this may not be practicable for the reason previously given.

NO one need be surprised if experts, who have been watching the naval fights between the United States and Spain, agree to assign to armour-piercing projectiles, fired at high velocities, a comparatively minor place in future warfare. We have had no example so far of rival ships or fleets engaging one another at five or six-mile range. If either fleet, in future conflicts, should desire to close with its adversary, the latter must either accept the challenge or run away. But if it accepts, and the fleets come to close

quarters, shells with service charges, instead of armour-piercing projectiles with battering charges, are likely to be most in demand, if the battle of Santiago is at all typical of what is to come. This is not to imply that very high velocities may not prove extremely useful in certain cases, or that the strongest gun, comparing the ratio between energy developed and total weight of gun, should not always be preferred, provided it has no drawbacks to counterbalance its increased efficiency. But we have all lived to see the theoretically preferable 110-ton guns discarded, even for land defences, where the question of weight was not so vitally important as on board ship, in favour of much lighter guns. Let us try to advance more slowly and surely with very high velocities, now that our thoughts have turned in that direction!

Two of the largest and best equipped railway systems in the United States are devoting serious attention to the problem of reducing the dead weight of their standard passenger coaches. The New York, New Haven and Hartford, one of these systems, which practically controls all the railways east of New York and south of Boston, has been giving effect to the impressions made on its president, C. P. Clark, during his visit to England two years ago. Mr. Clark said, after his return, that what struck him most favourably about the British railways was the lightness of the passenger rolling stock as compared with that in the United States. Apparently in accordance with his suggestion, Mr. E. E. Pratt, superintendent of buildings on the New Haven Railway, designed a model passenger coach with wrought iron fittings instead of cast iron, with lighter scantlings and with lighter floors. This car was put into service in November, 1896, and, up to January 1 last, had run 59,881 miles. Compared with the coach of the old pattern which it most nearly replaced it weighed about 52,000 pounds, as against 59,500, and it is expected that this weight will be further reduced by 250 pounds when the new coach gets aluminium fittings for the seats,—a purpose for which that metal seems well adapted,—instead of the iron frames used at present. But if the new coach shows itself by actual service to have no drawbacks, it will replace not only the standard New Haven one of 59,500 pounds, but also numerous others of a larger type weighing 65,000. This would mean a decrease in weight of more than 20 per cent. on the present heavier coaches, and 12½ per cent. on the lighter coaches. In other words, five of the new coaches could be hauled with the same coal consumption as four of the old ones in the former case, and eight instead of seven in the latter.

On the Illinois Central system, under the direction of Mr. Renshaw, superintendent of motive power, the process of turning out lighter passenger coaches has been developed on a larger scale, and perhaps in a more practical way, for some years past. Most of the old coaches on that system have from one to three tons of old rails placed beneath the floor of the coach which were put there to check horizontal swaying by lowering the centre of gravity, and consequently to make them smoother riding vehicles for the public. Every time one of these old coaches comes into the shop for a thorough repair Mr. Renshaw removes this dead weight of old rails. For two or three years past he has also substituted wrought iron for cast iron fittings in all the new coaches built under his direction. What is more, he finds that the saving in metal more than covers the additional cost of labour involved in making wrought iron fittings. Probably the time is approaching when we shall see mild steel everywhere employed for car fittings, as we see it to-day employed in all ship construction. As the relative tensile strengths of cast iron, wrought iron and steel are, respectively, 25,000 pounds, 50,000 pounds, and 80,000 pounds per square inch, this would mean a reduc-

tion of more than two-thirds the weight of cast iron, and nearly one-third the weight of wrought iron. The truth is that the vast improvement in the permanent way of the leading railways in the United States during the past ten years has rendered superfluous many of the adventageous aids once necessary for smooth riding. One has only to open Poor's Manuals for 1888 and 1898 to find many of the roads, catalogued in 1888 as using rails from 60 to 65 pounds to the yard, now credited with rails of from 90 to 100 pounds. This change permits of the use of lighter and more flexible springs, of the abandonment of dead weight not necessary to keep the car steady on the superior track, and of the use of lighter scantlings, because the wear and tear of the car from jolting is not so great. Parlour and sleeping cars, running, as they do, over roads good and bad, will not be able to take advantage of these facts until the small and impoverished roads are able to bring up their permanent way to the same level of excellence as those which are prosperous. Yet 100,000 pounds for a modern 72-foot sleeping car is a monstrous weight.

ACCORDING to present indications, the Krupp process of hardening armour plate for warships seems to be giving results superior to the older and better known Harvey process. Some trials recently made in the United States, at Washington, D. C., showed that projectiles with a striking velocity of 2000 feet per second passed clean through a Harveyised nickel-steel plate, while the striking velocity of a projectile of the same calibre had to be raised to 2350 feet per second before it passed through a Krupp nickel-steel plate of the same thickness. The rule in such cases is that a projectile will pass through as many inches of wrought iron for each thousand feet per second of striking velocity as it is inches in calibre. Thus a 6-inch projectile with 1000 feet per second of striking velocity will just perforate six inches of wrought iron; while with a striking velocity of 2000 feet per second it will just perforate twelve inches of wrought iron. As the resistance of Harveyised nickel-steel is exactly double that of wrought iron, we must use twice the striking velocity to perforate a plate of this material. We are now in a position to make deductions from the result of the recent Washington trials. It is evident that a projectile of the calibre used would have gone through a wrought iron plate of the same thickness as the two on trial with a striking velocity of 1000 feet per second. The relative resistance of Harveyised and Krupp armour plates is, therefore, taking wrought iron as 1, as 2 is to 2.35. This gives the plate made by the Krupp process at the Carnegie Steel Works, at Pittsburg, a slight, though positive, superiority over British armour plate made last year by the same process, the ratio being 2.35 to 2.33. Of course, it is understood that when the test is one of armour plate only, the question of the relative penetrative power of projectiles plays no part in it so long as these are able to perforate the armour without breaking up.

THE comparative figures, giving the resistance of different kinds of armour plate, which were arrived at after exhaustive tests by British experts in the latter part of the year 1897, are interesting. The experts agreed that wrought iron 14 inches thick; steel-faced armour, 11 inches thick; Harveyised nickel-steel armour, 7 inches thick; and Krupp nickel-steel armour, 6 inches thick were equal in resisting power. The saving in weight effected by the substitution of Harveyised or Krupp armour for wrought iron is enormous. To take a concrete instance, the British battle-ship *Victorious*, of the *Majestic* class, of 14,900 tons displacement, carries as armour 3025 tons of Harveyised steel. To obtain equal protection with wrought iron armour, the vessel would need just double that weight, or 6050 tons. But each ton of weight to be carried means at least a ton and a half

of displacement, so that even if the engines and boilers remained at their present size, the displacement of the *Victorious* would be increased from 14,900 tons to 19,437 tons.

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NOR is it likely that improvements in armour will now cease. France, Great Britain, the United States and Germany have each, in their turn, made important improvements in armour plate. France began in 1859 by placing hammered iron on *La Gloire*. Great Britain made the next advance in 1860, through Mr. (afterward Sir John) Brown's discovery that armour plate could be rolled. Then both nations worked at compound armour, and this reached its height in the eighties with a one-third hard steel face cast upon, or cemented to, a two-thirds wrought iron back. Though solid steel plates were made by Messrs. Schneider & Co. at Creusôt, France, as early as 1876, they never met with general acceptance for warships, owing to their liability to crack into pieces and smash up under repeated blows from heavy projectiles. Harvey was the first to make steel plates against which no objection could be made. The celebrated process which now bears his name consisted in heating armour plates of mild, tough steel for several weeks in a furnace, with their outer faces resting on a bed of charcoal and bone ash. The mild steel, as in the old case-hardening process, absorbed carbon and became supercarbonised to a depth of from 1 to 1¼ inches. The plates were then taken out and cooled down to a cherry-red heat, after which the whole surface was simultaneously sprayed with ice water, giving the outer surface of the plate a hardness sufficient to resist the action of a drill. The subsequent method of tempering these plates is still a trade secret.

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ALTHOUGH the United States began to manufacture armour only in 1886, they soon took the lead in this matter through the skill of the Bethlehem and Carnegie companies. The Harvey process was brought to such perfection there that all the nations of the world were forced to use Harveyised steel armour plate or confess themselves hopelessly beaten in the race. Close on the heels of Harvey's invention came the discovery of nickel-steel in the United States. This was an alloy, made by adding from 3 to 5 per cent. of nickel to the steel, and the result was a fine close-grained metal, with ductility almost equal to mild steel, while its power of resistance to the impact of projectiles was much greater. Nickel steel, with some precautions, can be face-hardened by the Harvey process in the same manner as ordinary steel. The Germans, though never far behind, did not reach the front rank until Krupp brought out his specially hardened steel, made under patents purchased from Schmitz & Ehrenberger in 1895. This is an alternative to the Harvey process, and while part of it is patented, the remainder of it is still kept a trade secret. Its superiority for gun-shields and thin armour was at once recognised in Great Britain, where several important firms purchased the right to manufacture it. In November, 1897, the Carnegie Company and the Bethlehem Company bought the rights for the United States; and the Carnegie Company, as has already been seen, promises to excel the original makers in its manufacture.

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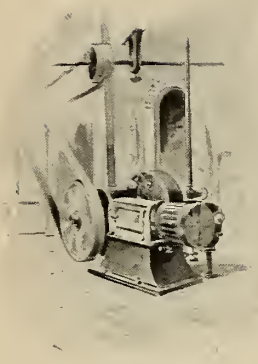
THE next step forward is likely to be the use of carbides in casting, in order to prevent blow holes. Aluminium has already been used for this purpose by the Carnegie Company and others, though the exclusive rights to its use for this purpose are claimed by the United States Mitis Company, under the Wittenstrom patent. The *rationale* of such processes seems to be the affinity of certain metals for oxygen, thus absorbing the gases occluded during the casting process. It is strange that Faraday detected aluminium in the celebrated Wootz or Indian steel half a

century ago, though subsequent analysts failed to confirm his results. This is by no means the first time that Faraday has thrown out a hint which subsequent experimentalists, to their great loss, have failed to follow up. It is a pity that he knew little or nothing about metallic carbides, but metallurgists of the present day would do well to watch Moissan's discoveries for practical applications.

LARGE-CALIBRE gun firing is pretty expensive work. According to recently published figures, for example, giving United States Navy particulars, a 13-inch gun, firing a 1100-pound shell, consumes 550 pounds of brown prismatic powder, costing from 30 to 33 cents per pound. At the lower price the powder for a single discharge costs $165. The common 13-inch shell is said to cost $116.63; but the armour-piercing projectile costs $418. To these items must be added cartridge-bags, primers, freight, etc., amounting to about $15; or, $296.63 for the shell discharge, and $588 for the discharge of an armour-piercing projectile. As the 13-inch gun can be discharged about 25 times in an hour, the work of one gun for an hour may cost the government about $15,000. The 8-inch gun costs about $65 for each shot; the 5-inch rapid-fire costs $33; the 6-inch breech-loading shot costs about $40, $14 being for the powder; and each round of a Hotchkiss 6-pounder gun is estimated to cost $5.70, and a 1-pounder, $1.12 Whitehead torpedoes cost $2500 each, and a Howell torpedo, $2200.

THE LATE JOEL SHARP.



MR. JOEL SHARP, whose death was announced a few weeks ago, was one of the old-school engineers, starting in lines remote from engineering, and yet, in later years, achieving honour and prominence in that profession.

His early years were spent on an Ohio farm. In 1834, at the age of fourteen, he went to Cleveland, spent a few years as clerk in grocery and dry goods shops, and ultimately engaged with his brother, Thomas, in the saw-mill business. In 1846 he entered the employ of the Cuyahoga Furnace Company, at Cleveland, as a machinist at $1.25 a day; but later again ventured into business on his own account in company with his brothers, opening a machine shop under the firm name of Sharp Brothers. Later a new firm was formed, known as Sharp, Davis & Bonsall, who built the original part of the plant now known as the Buckeye Engine Works, at Salem, Ohio.

The Buckeye Engine Company was organised and chartered about January, 1871, and Mr. Sharp was its president from the date of organisation up to the time of his death.

In 1885 the Salem Wire Nail Company was organised, and Mr. Sharp was elected to its presidency, which position he held until the recent reorganisation of the company as a part of the combination known as the American Steel and Wire Company, of Cleveland. To Mr. Sharp's sound judgment, mechanical skill and analytical powers of mind were very largely due the remarkable growth and success of both establishments.

For many years he was an honoured member of the American Society of Mechanical Engineers. His life work has been rich in fruits, and the world is, indeed, better for his long years of active and faithful service.

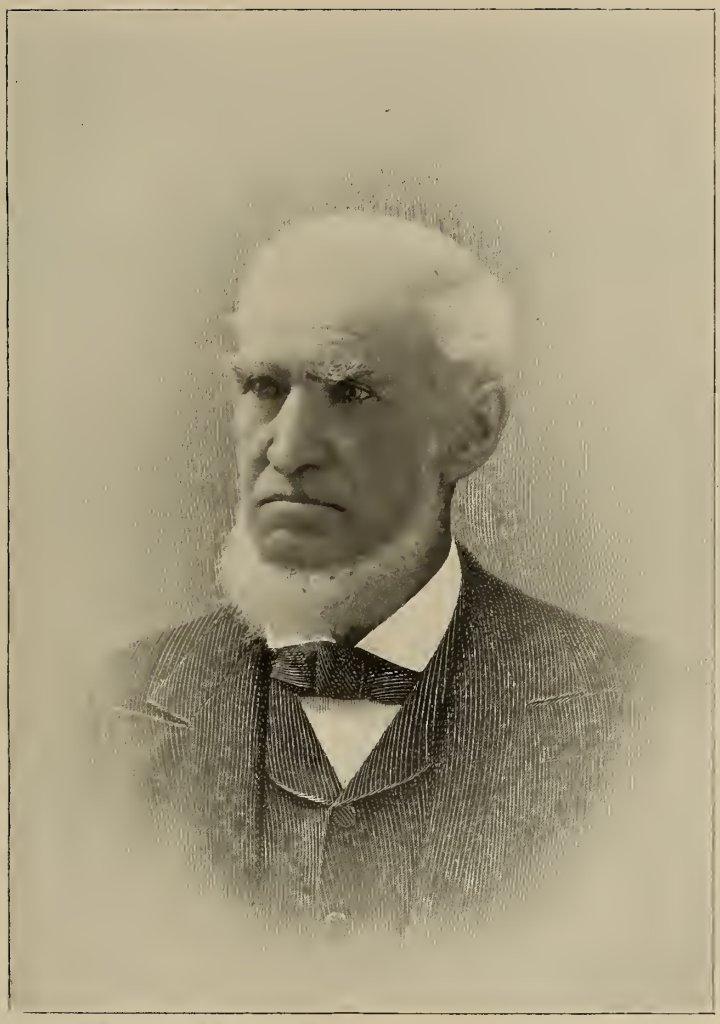
THE LATE ALBERT L. IDE.

A Biographical Sketch.

IT seems only a few weeks ago, even though it is a year, that news came of the death of Albert L. Ide. There was little premonition of his approaching end, and to a host of acquaintances and friends the sad tidings came with startling suddenness.

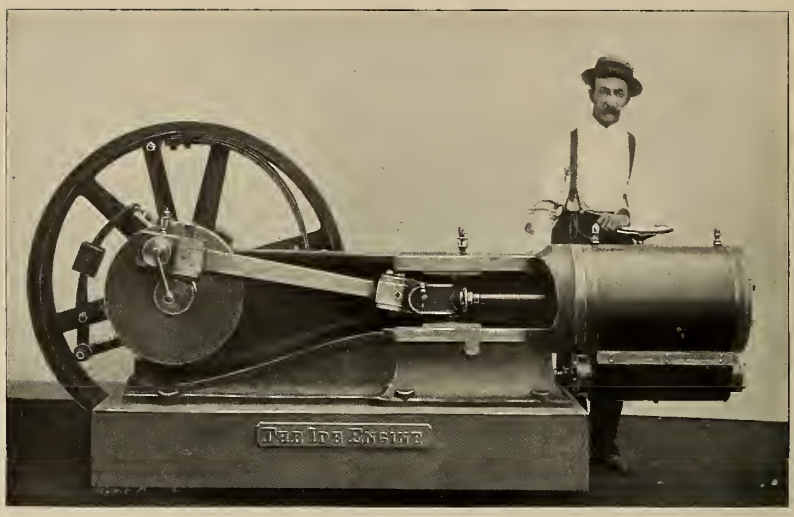
Mr. Ide was the senior partner of the firm of A. L. Ide & Sons, proprietors of the Ide Engine Works, at Springfield, Ill., president of the Springfield Electric Light and Power Company, a director of the Ridgeley National Bank and the Springfield Consolidated Railway Company. Under his management the Ide Engine Works gained a world-wide reputation, and its finished products secured sales in many foreign countries.

His success as a business man, an inventor and manufacturer was attained through the natural genius that stamped him as a mechanic of the very first order, coupled with sound business meth-



FROM A PHOTOGRAPH BY S. J. HEWETT, SALEM, OHIO.

THE LATE JOEL SHARP.



THE FIRST IDE ENGINE, WITH MR. IDE AT THE THROTTLE.

ods and unrelenting industry. He was ever in the lead. He was the first steam fitter that ever did business in the city of Springfield, in Illinois, and among his larger contracts was that of heating the present Illinois State Capitol. He was among the first to seize opportunities for improvements, and the effects of his genius and foresight are visible in many things that have marked the progress of Springfield.

Mr. Ide was born in Wapakoneta, Auglaize County, O., on March 20, 1841. He came to Illinois in 1843 with his father, L. H. Ide, and brothers, and lived on a farm near Williamsville until 1855, when he moved to Springfield. One of the many stories of his boyhood days on the farm illustrates his natural inventive and experimental mind. While his parents were attending church one day, he took a stick of wood, bored out a chamber and touch-hole and made a toy cannon, which he proceeded to test by loading it with powder and firing it off in the house, the result being an explosion of the cannon and the damaging of the plaster on the ceiling by the flying pieces, which damage he tried vainly to repair before the return of his parents. He repaired his neighbours' clocks in those days, doing it for the pleasure it gave him.

In 1856 he entered the shop of Campbell & Richardson, at Springfield, Ill., as an apprentice, and served three years there, beginning his education as a practical machinist. Steam engines for use in saw mills and grist mills were built in this shop, and there he gained his first experience in that department of engineering which was to engage his best activities in later years, and be the means of establishing his reputation as an inventor and designer.

He enlisted at the first call for troops in the Civil War in the Seventh Illinois Infantry, and at the expiration of service was drill master at Camp Butler, where he drilled troops for a year, again entering active service as Major of the Thirty-second Illinois Infantry. He was honourably discharged for disability after a severe attack of typhoid fever.

He subsequently clerked in a merchandise store, and by being economical and attentive to business, saved several hundred dollars. Henry C. Meyers, who was appointed sutler at Camp Butler, wished to dispose of his jewelry business and asked Mr. Ide to buy the stock, to which he replied that he had not enough money to pay for it. Mr. Meyers replied:—

"Pay me what you can, and the

balance out of the business as you make it."

He turned the stock over to Mr. Ide without any security in 1862. By good management Mr. Ide paid Mr. Meyers the balance, something over a thousand dollars, within a year or eighteen months, out of the profits of the business. After the close of the war he built and equipped the Springfield City Railway's Fifth Street Line and became president of the company.

He engaged in the steam heating business in 1870, and shortly after was awarded the contract for heating apparatus for the new Capitol building at Springfield. In 1876 he purchased from the city the Market House property on corner of Fifth and Madison Streets, under an agreement to operate a machine shop in the building for ten years, and equipped a much more complete and extensive machine shop and foundry than he had before possessed. This building was the nucleus about which has grown, by improvements and additions from time to time, the present extensive property constituting the Ide Engine Works. The steam heating business prospered and grew in the new plant, and many of the largest public institutions of the State of Illinois have heating and ventilating systems which were installed by him during this period.

About the year 1880 Mr. Ide became interested in the efforts which were then being made to perfect and to introduce in commerce a practicable system of electric lighting. To satisfy himself as to the probable success of this new industry, he went to Menlo Park to observe the results which had there been accomplished by Edison. Of this visit and the line of thought which it directed Mr. Ide has said:—

"When I first observed the lights, I noticed an unsteadiness and objectionable pulsation and variation of the intensity, and in a personal interview with Mr. Edison he informed me that this pulsation was occasioned by the unsteadiness of the power derived from the engine.

"We went in the engine room and I examined the engine. It was a Corliss engine, built, I think, at Providence, R. I., and Mr. Edison informed me that he had purchased one of the Corliss engines and had it made especially for his use because he believed it to be the best engine then made for giving the steady power required for driving electric lights. Each revolution of the engine could be counted by looking at the electric lights, some of which were several hundred feet away, in use in lighting the park. Mr. Edison stated that the governing and regulation of the engine was not satisfactory, and that a better governing and regulating device would be necessary before he could obtain a steady and satisfactory commercial light.

"This turned my mind in the direction of inventing or perfecting an engine suitable for electric lighting use, and one by which the difficulty referred to would be overcome. About one year from this time I purchased and placed in my works a Thomson-Houston 10-light dynamo, with ten lamps, for furnishing lights in merchants' stores in Springfield, and this dynamo was driven from the throttle-governed engine which was driving the machinery in the shop. These lights were not satisfactory on account of their unsteadiness.

"About one year from this time, or about the spring of 1881, I made up my mind that electric lighting would be a success and would come into general use for illuminating purposes, providing an engine could be obtained which could give the steadiness necessary to produce a satisfactory commercial light. I went to New York and investigated the different systems of electric lighting then being introduced, and decided to take the Western agency for the Fuller-Wood System of electric lights. I also informed myself in regard to the most suitable engines then being manufactured for the purpose of driving electric lights, being satisfied that the engine I was then building was not suitable for this use.

"The leading engines then thought most desirable for the purpose were the Armington & Sims, built at that time at Lawrence, Mass., and

formerly known as the Lawrence engine; the Porter-Allen engine, built by the Southwark Foundry and Machine Works, at Philadelphia; and the Hampson engine, sold by Edward P. Hampson, at New York. These engines all were of the type known as high-speed automatic engines. On further investigation, I found that the Hampson engine was manufactured by Messrs. W. B. Payne & Sons, then of Corning, N. Y.

I investigated this engine, and selected it as being as suitable as any engine then built for this use, and gave Messrs. Payne & Sons an order for several to be used for driving electric lights of the Fuller System. These engines had their governor in a light pulley-wheel on the shaft.

"I sold and placed a number of those engines in store buildings in Chicago for electric lighting. While satisfactory in the main, they did not give as good results in regulation as needed to meet the requirements for complete success in this service. Many improvements suggested themselves to me, and I then determined to undertake the design and construction of an engine of this class which would give a steady, reliable and satisfactory power for driving electric lights.

"I sold out my electric lighting business in Chicago and devoted my whole time and attention to designing, constructing, experimenting with, and perfecting a high-speed automatic engine that would fill the requirements for electric lighting purposes."

This work, full of details of most exacting kind, resulted eventually in the Ide engine practically as it is to-day. Besides the governing mechanism, Mr. Ide developed a self-oiling system for his engines. This, which was perfected about 1886, met with immediate approval, and was incorporated as one of the characteristic features of the new design of automatic high-speed engine, then christened the "Ideal," after the inventor's and designer's name with his initials added. It quickly gained a prominent position in the trade, and its history for the next decade was one of constant success. Improvements followed, one upon another, continuously and rapidly, and the finished product bears the impress of the inventor's skill exercised almost to his final hour, and stands as a monument to his industry and ability.

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